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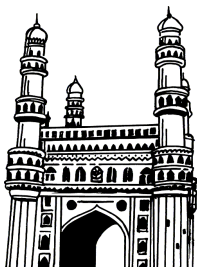

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UNIT I

Introduction

Similarities and Differences between Products & Services. Basic Manufacturing Process: Casting, Machining , Welding , shearing Extrusion , heat treatment and unconventional machining. The transformation Process: Manufacturing, Service & Hybrid Agile Manufacturing. Operations Strategy.

Process design – Project, Job, Batch, Assembly and Continuous. Factors effecting Process design. Functions of Production, Planning & Control. Interface of Product Life Cycle & Process Life Cycle.

1.1 Operation Management

Q1. What is operation management ?

Ans : **(Aug.-21)**

Introduction

Operation management is the management of systems or processes that create goods and/or provide services.

Operations management is a modern discipline which deals with the process of planning, designing, operating and managing the systems and subsystems of an organization for the achievement of organizational goals.

Definition

Operation management can be defined as "the branch of management that studies all the processes and systems that are undertaken for converting inputs into value added outputs".

According to the U.S Department of Education, "Operations management is the field concerned with managing and directing the physical and/or technical functions of a firm or organization particularly those relating to development, production and manufacturing".

1.1.1 Evolution/History of Operation Management

Q2. Explain the evolution / History of operation management.

Ans : **(Aug.-21, Imp.)**

1. **Industrial Evolution:** The evolution of modern operations management began when Adam Smith recognized the importance of division of labor, and the assigning of workers to tasks based on their individual skills and capabilities. The concept was adopted by Fredrick W. Taylor in his book "The Principles of Scientific Management".
2. **Scientific Management:** Fredrick W. Taylor introduced the concept of scientific management.

The concepts as follows :

- Each worker should be assigned a task based on his skill, and ability to learn.
- Standard output time is set for each task, using stopwatch studies. This should be used to plan and schedule future tasks.
- Instruction cards, routing sequences, and material specifications are used for coordinating the activities in a shop, and work methods and work flow should be standardized.
- Proper supervision by carefully selected and trained supervisors.
- Incentive pay systems to motivate workers.

3. **Moving Assembly Line:** In 1911, Henry Ford applied the principles of scientific management to a moving assembly line for the manufacture of the Model to Ford automobile by employing standardized product designs, mechanized assembly lines, specialized labor and interchangeable parts in production units. Ford was able to reduce the production time for a car. This was the

first successful implementation of scientific management principles. This application of principles of scientific management was thus used world wide.

4. **The Human Relationship Movement:** In the Plant of the Western Electric Company in the 1927-1932 period, Hawthorne Studies were conducted by industrial engineers and were aimed at determining the optimal level of lighting to get maximum output from workers.

   When these studies produced confusing results about the relationship between physical environment an worker productivity, the researchers realized that human factors must be affecting productivity. Thus for, the first time that researchers and managers alike, recognized that, psychological sociological factors affected not only employee motivation but their productivity as well.

5. **Operations Research:** At the beginning of World War II, Great Britain, desperately needed to solve a number of new and complex problems in warfare. With their survival at stake, the British formed the first OR teams by selecting the expertise of mathematicians, physicists and other scientists. With such teams, the British were able to achieve significant technological and tactical breakthroughs.

6. **Computers and Advanced Operations Technology:** Computerization has brought significant improvement in the production process. It was led to improvement in the quality of products and services, reduction in labor costs and wastage, increase in efficiency of the production process, etc.

7. **The Service Revolution:** The impact of service organizations on production management has been enormous. It is a challenge for manufacturing managers that they should formulate strategies and actions to manage service areas for better productivity, quality and competitiveness.

   It is a process technology is suitable for those manufacturers who produces goods or provides services in small batches of many different products as per the requirement of costumers i.e., custom design.

1.1.2 Nature of Operation Management

Q3. Explain the nature of Operation Management.

Ans :

Nature of operations management can be studied as follows :

1. Production as a System

As the main function of an operations system is to convert or transform a set of inputs into outputs, it is considered as a system. In production, a set of inputs constitute a production system, their conversion into desired products constitute a conversion-subsystem and a portion of output which has to be analysed in terms of cost, quality and quantity constitutes a control subsystem.

2. Production as an Organizational Function

The conversion subsystem is considered as the core component of any production system as it uses men, materials and machines for converting inputs, into outputs (finished goods). Production has become an integral part of every organization wherein personnel and departments are playing pivotal role in achieving the objectives of an organization.

3. Decision Making in Production

The Production/Operations manager has to make a series of decisions related to production as they are responsible for planning, organizing, staffing and controlling the entire process of production. These decision are divided into three different categories,

(a) Strategic Decisions : These decisions are long term in nature and are of strategic importance. They may be related to production processes, production technology, facility layout, allocating scarce resources etc. These decisions provide answers to question like - How much to produce, where to produce, when to produce, and so on.

(b) Operational Decisions : Such decisions are made to efficiently fulfill the market demand for products and services. It basically includes planning decisions. These decisions ensure

that the organisation is producing goods and services as per the requirements of the market, thereby, generating reasonable profit for the organisation. The operational decisions are taken in production planning system, materials management, shop floor planning, demand inventory system etc.

(c) Control Decisions : These decisions are basically taken by the production for planning and controlling the day-to-day production activities. Such decision are taken based on the quality of the product/service, productivity of workers, maintenance of machines and tools and so on.

Therefore, one can say that the nature of operations management is very wide as it covers all the areas of production like planning, designing, operating and managing the production system.

1.1.3 Scope of Operation Management

Q4. Explain the scope of operation management.

Ans :

Scope of Operations Management

Due to the dynamic change in the business environment, the scope of production and operation management has increased. Following are the activities which are included under production and operations management functions :

Fig. : Scope of production and operations management

1. **Facility Location:** Selecting appropriate location for the production
2. **Plant layouts and material handling:** Deciding upon the machines, equipment and necessary devices which could lead to effectual and desired production in the most economic way. Preparation of plan layout for the establishment of machines in the required sequence. Storage of material and handling it in most effective way to avoid the wastage and delivery at the work centers as and when required.
3. **Product design:** Designing the product and conceive the idea about its production.
4. **Process design:** Determination of the production process which is most relevant and efficient in the given state of affairs.
5. **Production and planning control:** Planning the production and its various aspects how, when and where producing a particular product or its assembly will be done.
6. **Quality control:** Controlling the production and ensuring the quality by setting the check points and taking the periodic measurements of the current performance.
7. **Materials management:** Managing the inventories of raw material, semi-finished and finished goods in a way that neither excessive money may block in this non-productive operation nor the required material.
8. **Maintenance management:** Analysis the deviations and formulating the corrective measures to stay in track with planned quality, time-schedule and predetermined cost schedules.

1.1.4 Objectives of Operation Management

Q5. State the objectives of operations management.

Ans :

Objectives of Operation Management

Operation Management involves management of the entire process responsible for converting inputs into outputs**.** The following are the objectives of Operations Management.

1. To provide customer service

The main objective of any operating management systems is to utilize resources judiciously for the satisfaction of customer needs and wants. Therefore, customer satisfaction is a key objective of operations management. Operation management focuses on providing the right products at a right price at the right time. Hence, this objective will influence the operations manager's decisions to achieve the required customer service.

2. Effective utilization of resources

Resources that are used in the business organisation must be carefully utilized. Inefficient use of resources or inadequate customer service leads to commercial failure of an organisation. Operations management is concerned essentially with the utilization of resources. It aims at obtaining maximum output from the available resources with minimum cost.

3. To reduce cost of production

Operation management aims at reduction in the cost of production of goods and services. The cost per unit of the product has to be set properly and all efforts should be taken to control the actual cost to pre-determined cost of production. Cost can be classified in to fixed cost and variable cost. The variable cost changes with every level of production. This variable cost can be checked by means of inventory and labour control techniques.

4. To improve product quality

Quality control and maintenance are the two important objectives of operations management. Quality control consists of all those activities, which are designed to define, maintain and control specific quality of products within reasonable limits. It is the systematic regulation of all variables affecting the goodness of the final product. In other words, quality control involves determination of quality standards and its actual measurement .It is necessary to ensure that the established standards are practiced and maintained. It does not attempt to achieve the perfect quality but to secure satisfactory or reasonable quality at a reasonable level of cost.

5. To fix time schedule

Another important objective of operation management is to establish time schedule for various operation activities. The schedule fixation includes the operating cycle time, inventory turnover rate, machine utilization rate, capacity utilization etc.

6. Proper utilization of Machinery

Operation management has to take number of decisions with regard to machinery and equipment. New machines should be installed and the old machines are to be replaced. It has to ensure judicious utilization of machinery and equipment.

7. Material control

Based on the sales forecast and production plans, the materials planning and control is done. This involves estimating the individual requirements of parts, preparing materials budget, forecasting the levels of inventories, scheduling the orders and monitoring the performance in relation to production and sales.

1.1.5 Role of Operation Manager

Q6. Explain the role of operation manager.

Ans :

Almost all decisions regarding production are taken by the POM manager. At the same time he also plays a crucial role in many other areas/fields. These areas include,

1. Planning

It is the operations manager responsibility to decide the plant layout of the factory production strategy and the production design. Beside this, operations managers are also responsible for framing the policies and procedures to be used during production process.

2. Organizing

The operations manager organizes all the production activities and divides the work

flow among the workers. He makes sure that there exist smooth relationship among the workers and monitors the supply chain management.

3. Controlling

Controlling is another important role of the operations manager wherein he checks and controls the stock inventory, cost and the lead time. Maintaining the quality and quantity of goods as per standards are also taken care by the operations manager.

4. Inspection and Evaluation

Unlike previously, now-a-days, the quality is checked by a separate department rather than production department. This is because, the production department may simply ignore and neglect quality defects in order to safeguard themselves from the trouble. However it is the operations manager role to evaluate all the operations and make improvements where ever necessary.

5. Despatching Documents

The operations manager records and maintains all the important documents like job cards, route cards, inspection cards, and the like which are issued in time so that the production can be carried out smoothly.

6. Material, Machine and Equipments

The operations manager must take decisions about the quantity and quality of raw materials to be purchased, so that right kind of products are produced. He is the authorized person to place orders for machinery, tools and other equipments.

Emerging New Role

With LPG (Liberalisation, Privatisation and Globalisation) revolution, the world has become a global village. Severe and cut throat competition has conveyed a message that in order to survive, everyone in the organization must go "the extramile".

Today, operations manager in India also participating in the strategic decision making, establishing long term relationship with suppliers, upgrading the organizations with changing technology and self-evaluating their departments with the help of quality certificates like ISO 9000, ISO 14000, six sigma and others.

1.1.6 Recent Trends in Production / Operation Management

Q7. What are the recent trends in production /Operation Management

Ans :

Many recent trends in production/operations management relate to global competition and the impact it has on manufacturing firms. Some of the recent trends are :

1. **Global Market Place:** Globalisation of business has compelled many manufacturing firms to have operations in many countries where they have certain economic advantage. This has resulted in a steep increase in the level of competition among manufacturing firms throughout the world.
2. **Production/Operations Strategy**: More and more firms are recognizing the importance of production/operations strategy for the overall success of their business and the necessity for relating it to their overall business strategy.
3. **Total Quality Management (TQM):** TQM approach has been adopted by many firms to achieve customer satisfaction by a never-ending quest for improving the quality of goods and services.
4. **Flexibility:** The ability to adapt quickly to changes in volume of demand, in the product mix demanded, and in product design or in delivery schedules, has become a major competitive strategy and a competitive advantage to the firms. This is sometimes called as *agile manufacturing.*

5. **Time Reduction :** Reduction of manufacturing cycle time and speed to market for a new product provide competitive edge to a firm over other firms. When companies can provide products at the same price and quality, quicker delivery provide one firm competitive edge over the other.

6. **Technology :** Advances in technology have led to a vast array of new products, new processes and new materials and components.

   Automation, computerization, information and communication technologies have revolutionized the way companies operate. Technological changes in products and processes can have great impact on competitiveness and quality, if the advanced technology is carefully integrated into the existing system.

7. **Worker Involvement** : The recent trend is to assign responsibility for decision making and problem solving to the lower levels in the organisation. This is known as employee involvement and empowerment. Examples of worker involvement are quality circles and use of work teams or quality improvement teams.

8. **Re-engineering** : This involves drastic measures or breakthrough improvements to improve the performance of a firm. It involves the concept of clean-slate approach or starting from scratch in redesigning the business processes.

9. **Environmental Issues** : Today's production managers are concerned more and more with pollution control and waste disposal which are key issues in protection of environment and social responsibility. There is increasing emphasis on reducing waste, recycling waste, using less-toxic chemicals and using biodegradable materials for packaging.

10. **Corporate Downsizing (or Right Sizing)** : Downsizing or right sizing has been forced on firms to shed their obesity. This has become necessary due to competition, lowering productivity, need for improved profit and for higher dividend payment to shareholders.

11. **Supply-Chain Management :** Management of supply-chain, from suppliers to final customers reduces the cost of transportation, warehousing and distribution throughout the supply chain.

12. **Lean Production** : Production systems have become lean production systems which use minimal amounts of resources to produce a high volume of high quality goods with some variety.

    These systems use flexible manufacturing systems and multi-skilled workforce to have advantages of both mass production and job production.

1.2 Similarities and Difference between Products and Services

Q8. Explain the similarities between Products and Services.

Ans : **(Feb.-21, Aug.-19, Imp.)**

1. The design of both products and services is an outcome of human creativity.
2. Both products and services are designed to provide a solution, satisfaction or benefit to customer.
3. Promotional media is used by both products and services for their promotion.
4. To increase the sale of products and services, personal selling techniques are used.
5. Ascertaining customer's wants and needs with respect to products and services is a difficult task.
6. Customer satisfaction attained from products and services can be evaluated through surveys.

Q9. Compare and contrast product and services.

Ans : **(Feb.-21, Aug.-19, Jan.-18, Imp.)**

Products	Service
i) Products are tangible in nature	i) Services are intangible in nature
ii) Products can be stored and transported	ii) Services cannot be produced beforehand
iii) They are produced in a factor environment	iii) Services are produced in a market environment
iv) Products are mainly standardized	iv) Services are often customized
v) Quality is inherent in the product	v) Quality is inherent in the process
vi) Products have resale value	vi) Services does not have resale value.

1.3 BASIC MANUFACTURING PROCESS

Q10. Discuss about basic manufacturing process.

Ans :

Manufacturing Processes and Classification

Manufacturing processes are the steps through which raw materials are transformed into a product. The manufacturing processes can be broadly classified into three categories viz. *shaping*, *joining* and *finishing processes* as shown schematically in *Figure.*

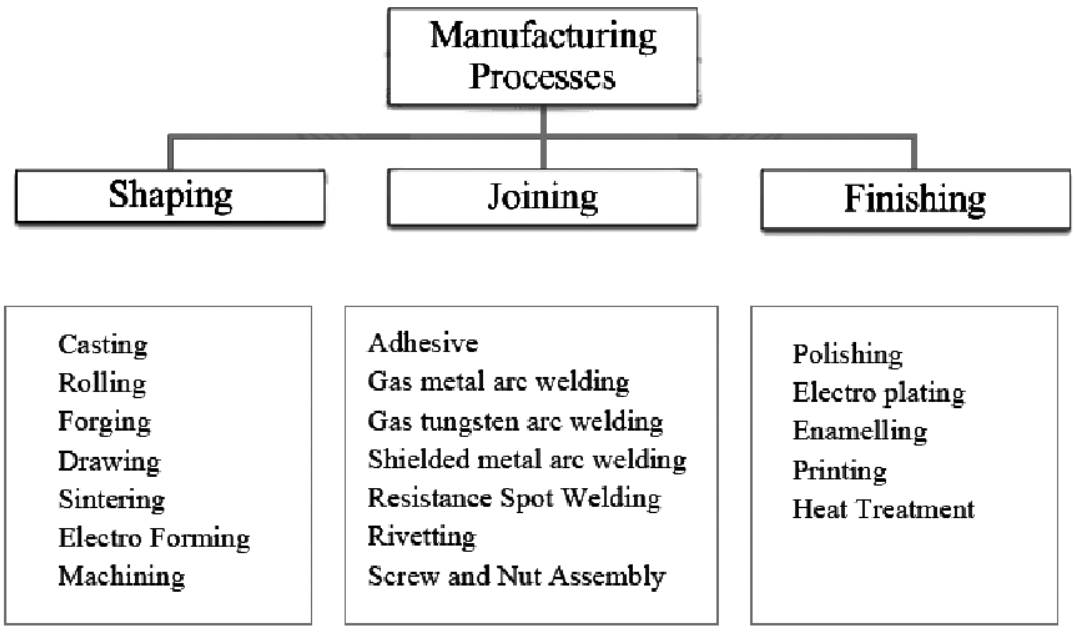


Fig. : Different classes of manufacturing processes

But the basic manufacturing process consist of the following concepts,

1. Casting
2. Machining

3. Welding
4. Shearing Extrusion
5. Heat Treatment
6. Unconventional Machining

1.3.1 Casting

Q11. Define casting? What are the steps involved in casting?

Ans :

Casting is the process for obtaining desired component by pouring molten metal in the mould cavity and allowing it to solidify.

Steps Involved in Casting

The various steps involved in making a casting are as follows,

1. Pattern preparation
2. Moulding
3. Melting and pouring the metal
4. Solidification
5. Removal of casting and feeling
6. Machining
7. Heat treatment
8. Finishing.

1. Pattern Preparation

A pattern is the replica of the final product required. Therefore, depending upon size, shape and casting process a pattern is prepared with either wood, metal or wax. Thus, pattern prepared must include all the allowances to obtain a sound casting.

2. Moulding

It is the main step as this involves making of cavity. The steps involved in moulding are as follows,

i) Initially, drag is placed in the inverted position on moulding table as shown in figure.

ii) Pattern is then placed in suitable position inside the drag.

iii) Parting sand is sprinkled on the pattern and all over the drag.

iv) Facing sand is poured only on pattern and it is pressed thoroughly on the pattern so that every detail of pattern is obtained.

v) Backing sand is poured all over the drag and then rammed thoroughly. This is repeated till sand level reaches the surface of drag.

vi) Ramming should be done- all over the drag to get a better mould cavity.

vii) The excess sand can be removed using strike-off bar, to maintain a perfect surface level.

viii) Using a vent rod, vent holes are made which allows the air to escape.

ix) Now, the drag is again reversed back as shown in figure (1). (Final position of drag).

x) Cope is placed exactly above the drag and then parting sand is sprinkled over the pattern and sand.

xi) The sprue and riser are placed in position in the cope.

xii) Sprue is placed beside the pattern, whereas the riser should be directly above the pattern.

xiii) Facing sand is poured around sprue and riser and pressed thoroughly to obtain steady position.

xiv) Backing sand is poured all over cope and ramming is done.

xv) Excess sand is removed using strike-off bar and then venting is done.

xvi) Sprue and risers are removed and pouring basin is cut using a gate cutter near the sprue.

xvii) Cope is lifted and kept aside. Figure (2) shows the arrangement of cope and drag, after cutting runner and ingate in the drag.

xviii) The pattern is slowly removed without disturbing the cavity.

xix) Again cope is placed over the drag. Thus, moulding is obtained i.e., cavity is obtained.

3. Melting and Pouring the Metal

a) Required metal is melted in oil furnace and then using the saddles molten are poured into cavity.

b) Molten metal is poured with uniform velocity as to obtain sound casting.

4. Solidification

In this step, after molten metal is poured, it is allowed to cool for certain duration, so that induced stresses can be reduced.

Solidification time actually depends on volume and surface area of casting.

5. Removal of Casting and Fetling

After the metal gets solidified, casting is removed from the mould and fetling is done. Fetling is cleaning operation of the cast using a brush to remove the sand particles on it.

6. Machining

a) The casting obtained has sprue, risers, ingates, basewell and pouring basin.

b) Thus, in this step all these are removed and desired product is obtained.

7. Heat Treatment

The casting so obtained may have stresses induced in it which may later affect the performance of the casting product.

Thus, heat treatment is done to relieve these induced stresses.

8. Finishing

It is the last step of casting process to obtain the dimensional accuracy and surface finish.

Q12. What are the advantages, disadvantages and applications of casting.

Ans :

Advantages

1. Complex shapes can be produced by casting whereas it is not possible by other manu-facturing processes.
2. There is no restriction to the type of metal to be casted as in other production processes there may be restrictions (Eg: Welding).
3. The plastics material can be casted very easily.
4. Surface finish of the product obtained by casting is too high.
5. Machining cost can be reduced.
6. Component achieves good mechanical properties after casting.
7. Cost of casting can be reduced by using mechanical and automatic casting process.
8. Large number of castings can be casted at a single time which intum increases the productivity.

Disadvantages

1. Time taking process.
2. In metal casting, metal needs to be melted which is a high energy consuming process.
3. The productivity is less than the other automatic processes, such as rolling.

Applications

Automobile engine blocks, cylinder blocks of automobile and aeroplane engines, pistons and piston rings, machine tool beds and frames, mill rolls, wheels and housings of steam and hydraulic turbines, turbine vanes and aircraft jet engine blades, water supply and sewer pipes, sanitary fittings and agricultural parts etc.

1.3.2 Machining

Q13. Describe the categories of machining?

Ans :

Machine Tools are stationary power-driven machines used to shape or form solid materials, especially metals. The shaping is accomplished by removing material from a workpiece or by pressing it into the desired shape. Machine tools form the basis of modern industry and are used either directly or indirectly in the manufacture of machine and tool parts.

Machine tools may be classified under three main categories:

1. Conventional chip-making machine tools.
2. Presses.
3. Unconventional machine tools.

1. **Conventional chip-making machine tools:** Conventional chip-making tools shape the workpiece by cutting away the unwanted portion in the form of chips.
2. **Presses :** Presses employ a number of different shaping processes, including shearing, pressing, or drawing (elongating).
3. **Unconventional machine tools :** Unconventional machine tools employ light, electrical, chemical, and sonic energy; superheated gases; and high-energy particle beams to shape the exotic materials and alloys that have been developed to meet the needs of modern technology.

General Lathe Machine Operations

The following are the general operations, that are performed on lathe machine,

1. Turning (cylindrical or conical workpieces)
2. Facing
3. Grooving
4. Drilling
5. Reaming
6. Counter sinking and counter boring
7. Knurling
8. Parting
9. Thread cutting
10. Chamfering
11. Spinning
12. Undercutting
13. Milling
14. Slotting
15. Grinding
16. Taper turning
17. Scrolling
18. Spring winding and
19. Relieving
20. Keyway cutting

Classification of Modern Machining Processes

The modem machining processes are classified based upon the following categories,

1. **According to the type of energy**
   i) Mechanical
   ii) Chemical
   iii) Electro-chemical
   iv) Electro thermal.

2. According to the mechanism of metal removal

i) Shear

ii) Erosion

iii) Spark erosion

iv) Vaporization

v) Ionic dissolution

vi) Chemical ablation etc.

3. According to source of energy

i) Elydrostatic pressure

ii) High current density

iii) High voltage

iv) Ionized material

v) Corrosive agent etc.

4. According to the medium for energy transfer

i) High velocity particles

ii) Electrolyte

iii) Electrons

iv) Hot gases

v) Radiations etc.

1.3.3 Welding

Q14. Explain the classification of welding.

Ans :

Welding is defined as a technique of joining two dissimilar or similar metals by the application of heat and pressure. Welding processes are broadly classified into two types. They are,

1. Plastic (or) Pressure welding process
2. Fusion welding process.

1. Plastic (or) Pressure Welding Process

In pressure or plastic welding process, the metal to be joined are heated to plastic state and then external pressure is applied. This process is used in resistance welding, forge welding, thermit welding etc.

2. Fusion Welding Process

In fusion welding process, the metal to be joined is heated to molten state and allowed it to solidify. This process is used in gas welding, arc welding etc.

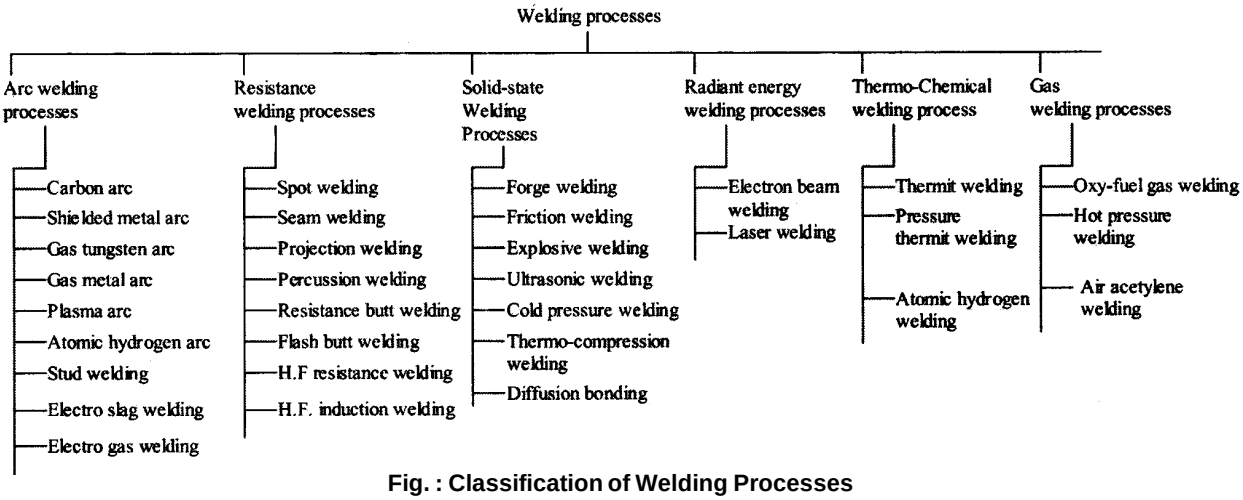


Fig. : Classification of Welding Processes

Some of the welding processes are defined below,

a) Gas Welding : Fusion welding process is used in gas welding, where two metals are joined by burning a combustible gas with air or oxygen in a concentrated flame of high temperature. Filler rod may be used to fill up the cavity during welding process.

b) Arc Welding : It is also a fusion welding process in which two metals are joined by heating with an electric arc to the melting temperature and then allowed it to solidify. Depending upon the thickness of base plate, filler metals may be used.

c) Resistance Welding : It is a pressure or plastic welding process, in which two metals are joined by passing a low voltage and very high current through the joint which melts the metals due to their contact resistance. External pressure is used to complete the weld. No filler metal is used.

d) Solid State Welding : It is a pressure or plastic welding process in which two metals are joined by heating the metal below its melting point temperature and then external pressure is applied.

e) Thermo-chemical Welding : It is primarily a pressure or plastic welding process in which two metals are joined by heat of thermit reaction and external pressure is applied to complete the weld.

f) Radiant Energy Welding : It is a fusion welding process in which a beam of electron strikes the surfaces to be joined and produces heat which causes the metals to melt and fuse.

1.3.4 Shearing Extrusion

Q15. Explain the concept of shearing extrusion.

Ans :

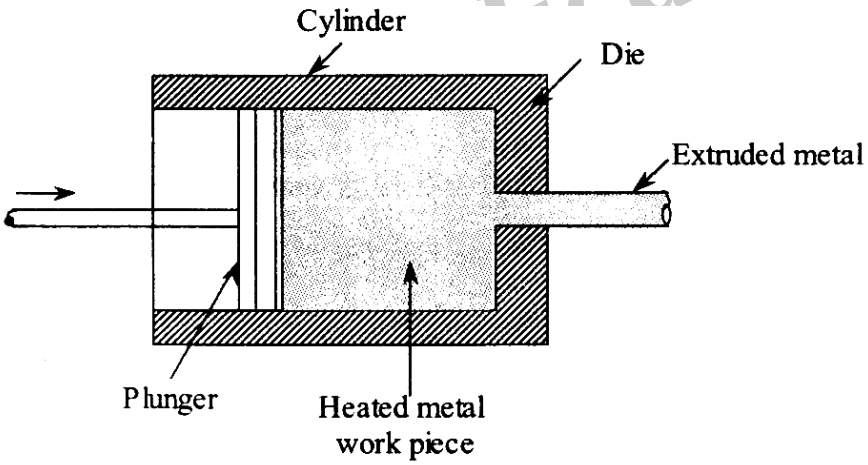
The concept of shearing extrusion consist of the following features,

1. Any cross-sectional shape can be extruded from the non-ferrous metal.
2. So extrusions can offer savings in both metal and weight.
3. Cross-sectional shapes are not possible by rolling.

4. A lot of time is lost when changing of shapes takes place. Since, the dies may be readily removed and replaced.
5. Dimensional accuracy of extruded parts is generally superior to that of rolled ones.
6. The range of extruded items is very wide and rods from 3 to 250 mm in diameter, pipes of 20 to 400 mm in diameter and wall thickness of 1 mm and above contains more complicated shapes which cannot be obtained by other mechanical working methods.
7. Very large reductions are possible as compared to rolling, for which the reduction per pass is < 2.
8. Automation of extrusion is simpler as items are produced in a single passing.

The extrusion equipment consists of a cylinder or container into which the heated metal workpiece is loaded as shown in figure. A die plate is fixed at one end of the container and the other end consists of a plunger or ram. The ram compresses the metal in the container and forces to flow through the die opening. The extruded metal coming out of the die acquires the shape of die and is carried by the metal handling system.

A dummy block with a diameter slightly less than the container is kept between the hot workpiece and the ram to protect it from the heat and pressure. The important parameter is the extruding force that depends on the material of the workpiece, extrusion ratio between the workpiece to chamber, die surfaces and process variables such as temperature of the workpiece, the extrusion speed.



The extrusion speed depends on the material of the work. High speed of extrusion results in excessive heat generation and causes cracking. At low extrusion speeds greater cooling of the workpiece occurs.

1.3.5 Heat Treatment

Q16. Define the term heat treatment? Discuss the various stages in heat treatment cycle?

Ans :

"A combination of heating and cooling operations timed and applied to a metal or an alloy in the solid state to produce desired properties" is known as heat treatment. Heat treatment involves transformation or decomposition of austenite and the products obtained will determine the physical and mechanical properties. Heat treatment of steel involves, heating the material to a temperature above the critical range to form austenite. Heat treatment depends on,

- The temperature to which the material is heated.
- Rate of cooling.

Reasons for Heat Treatment

1. To produce required combination of microstructure and mechanical properties to fulfill its purpose.
2. Increases the corrosion and wear resistance, improves machinability, surface conditions and mechanical properties by refining the grain size, for relieving the internal stresses and softening the material. Various heat treatment processes used to modify the structure and properties are annealing, normalizing, hardening, tempering and surface hardening.

Stages in a Heat Treatment Cycle

The process employed for controlled heating and cooling of the given material to change its microstructure and properties is termed as "heat treatment". In general, a heat treatment cycle has three stages. They are,

1. Heating
2. Soaking (maintaining the heat at constant rate) and
3. Cooling.

1. Heating

Steel is heated to austenite temperature at which its microstructure changes to austenite. The process used are annealing and normalizing.

2. Soaking

The temperature of austenite is held for a sufficient period to allow a uniform change in the properties throughout the cross-section and it carried out by austenizing.

3. Cooling

Steel from the austenite temperature is then cooled to room temperature. The rate of cooling depends on the desired properties associated with change in the size, form and nature. Examples are ferrite, pearlite etc. The purpose of heat treatment is to obtain a required microstructure, mechanical or physical properties of the steel being heat treated. Some of the purposes for heat treatment of steels are,

i) To relieve the internal stresses developed during cold working, casting, forging etc.

ii) Improve the hardness and strength.

iii) Improve electrical and magnetic properties.

iv) Improve ductility and toughness.

v) Soften the metals for other uses (cold working, rolling).

1.3.6 Unconventional Machining

Q17. Explain the classification of unconventional machining.

Ans :

Material Removal Processes can be Divided into Two Groups

1. Conventional Machining Processes
2. Non-Traditional Manufacturing Processes or Unconventional Machining processes

1. Conventional Machining Processes

Conventional Machining Processes mostly remove material in the form of chips by applying forces on the work material with a wedge shaped cutting tool that is harder than the work material under machining condition.

2. Non-Traditional Manufacturing Processes (or) Unconventional Machining processes

Non-conventional manufacturing processes is defined as a group of processes that remove excess material by various techniques involving mechanical, thermal, electrical or chemical energy or combinations of these energies but do not use a sharp cutting tools as it needs to be used for traditional manufacturing processes. Material removal may occur with chip formation or even no chip formation may take place. For example in AJM, chips are of microscopic size and in case of Electrochemical machining material removal occurs due to electrochemical dissolution at atomic level.

Need for Unconventional Machining Processes

- Extremely hard and brittle materials or Difficult to machine material are difficult to Machine by traditional machining processes.
- When the work piece is too flexible or slender to support the cutting or grinding Forces when the shape of the part is too complex.

Classification of UCM Processes

1. Mechanical Processes

- Brasive Jet Machining (AJM)
- Abrasive Water Jet Machining (AWJM)
- Water Jet Machining (WJM)
- Ultrasonic Machining (USM)

2. Electrochemical Processes

- Electrochemical Machining (ECM)
- Electro Chemical Grinding (ECG)
- Electro Jet Drilling (EJD)

3. Electro-Thermal Processes

- Electro-discharge machining (EDM)
- Laser Jet Machining (LJM)
- Electron Beam Machining (EBM)

4. Chemical Processes

- Chemical Milling (CHM)
- Photochemical Milling (PCM)

Q18. Explain the applications of unconventional machining.

Ans :

1. This process is best suited for machining hard and brittle materials.
2. Cutting thin sections of hard material without any distortion.
3. These methods are very useful for machining metals which have low thermal conductivity and high melting point.
4. Micro drilling in hard materials like tungsten and ceramics.
5. Cutting complex geometries on the thin surface films for making integrated circuits.

Q19. What are the advantages of Unconventional machining processes?

Ans :

1. These methods are capable of machining metals and alloys irrespective of hardness, brittleness, strength and toughness of the materials.
2. Complex geometries and intricate shapes can be machined easily through this process.
3. The machined surface is free from burrs and residual stresses.
4. Brittle materials with high hardness can be machined.
5. Closed tolerances upto 0.05 mm can be easily obtained by these methods.
6. High surface finish in the range of 0.1 to 0.2 microns can be obtained.
7. Negligible wear of the tool.
8. Work material is not subjected to any distortions.
9. Metal removal rate is high compared to traditional machining.

1.4 THE TRANSFORMATION PROCESS : MANUFACTURING, SERVICE AND HYBRID

Q20. Discuss the transformation process in manufacturing, service and hybrid organization.

Ans : **(Nov.-20, Imp.)**

The product or service organizations convert inputs into outputs and the process of converting inputs into outputs is known as transformation process. The quality of inputs is to be observed for obtaining the desired output. The quality of output that is actually acquired is frequently compared with the desired output.

Feedback Mechanism

Feedback mechanism is necessary to observe the performance of transformation process. While transforming the inputs into outputs, some unexpected disturbances obstruct the transformation process.

These unexpected disturbances are mainly caused due to external environment and are sudden or unplanned. The following figure depicts the feedback mechanism of transformation process.

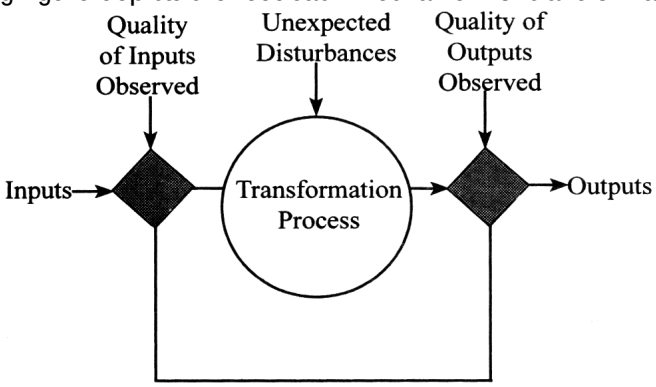


Fig.: Feedback Mechanism of Transformation Process

1. Transformation Process for Manufacturing Organization

Transformation process of a refrigerator manufacturer which is purely manufacturing organizations is as follows,

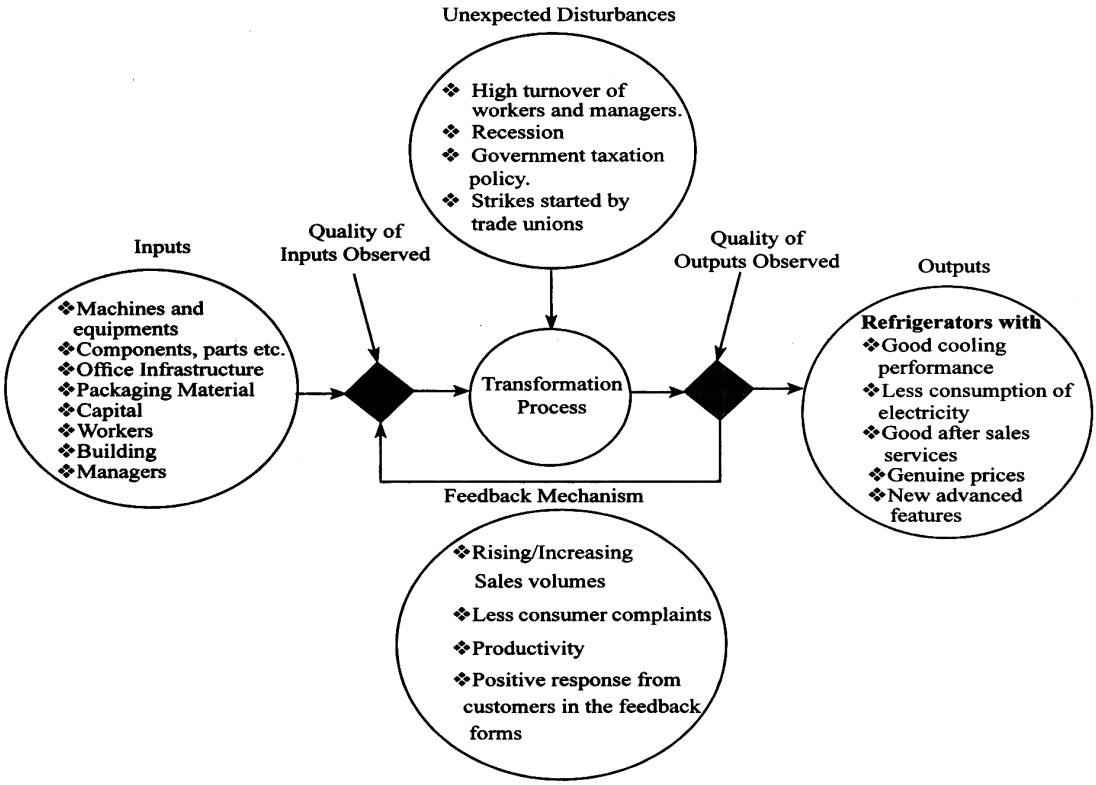


Fig. : Transformation Process of a Purely Manufacturing Organisation (A Refrigerator Manufacturing)

2. Transformation Process for Service Organization. The transformation process of an MCA Institution (a purely service organizaton) is given below,

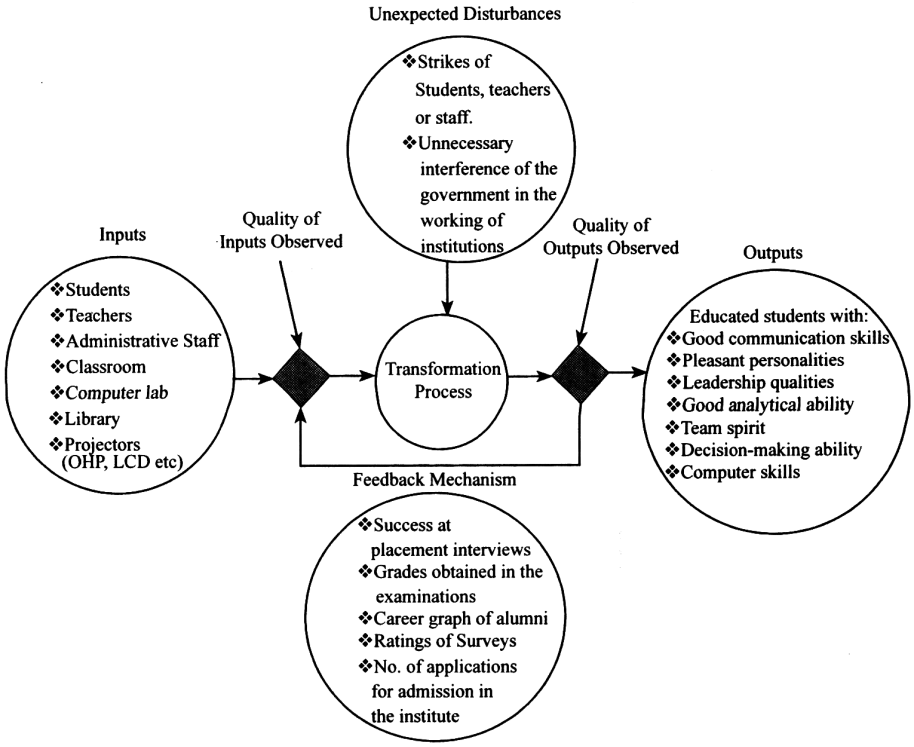


Figure: Transformation Process of Purely Service Organization

3. Transformation Process for Hybrid Service and Manufacturing Organization. The transformation process of a restaurant which is hybrid service and manufacturing organizations is shown below,

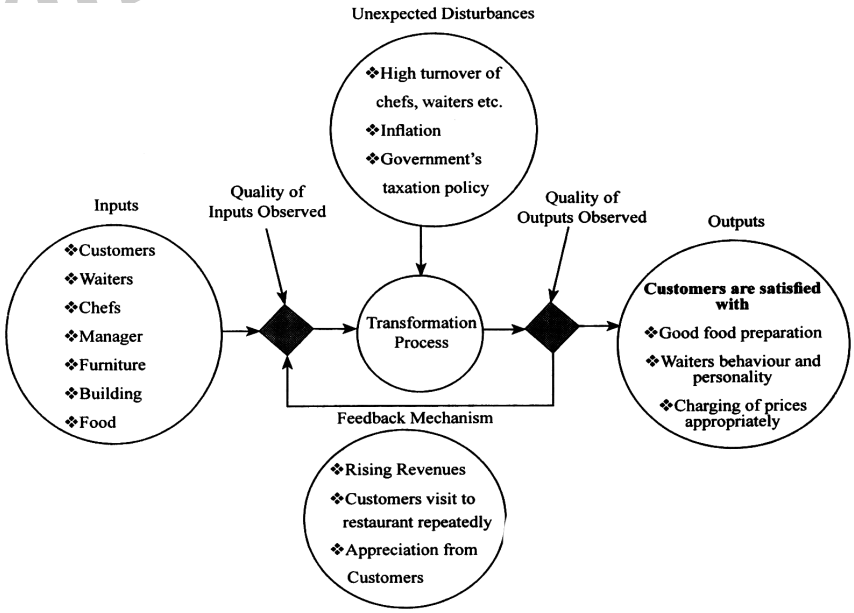


Figure: Transformation Process for Hybrid Service and Manufacturing Organization

1.5 AGILE MANUFACTURING

Q21. Define agile manufacturing ? What are the approaches of agile manufacturing.

Ans : **(Sep.-22, Imp.)**

Agile Manufacturing

Agile manufacturing is a method of manufacturing system which is entirely different from that of the lean manufacturing. Unlike lean manufacturing, it is used for the products whose production cannot be controlled.

Agility is the capacity to change the ideology according to the changing conditions or flexibility in the methods according to the rapid changing environment. Agile manufacturing is defined as a flexible manufacturing method which is being used to produce goods and services in order to meet the changing customer's needs and expectations quickly and effectively. The change in manufacturing system from mass production to agile manufacturing is due to following reasons,

a) Increase in competition across the world
b) Market fragmentation
c) Increased cooperation among the companies
d) Growing needs and expectations of customers
e) Reduction in product life cycle time, lead time and development time
f) Increased focus on customers.

The change in manufacturing towards the production of products or services with (less) reduced lead times results in number of problems of inventory, efficiency of plant, overhead and so on. Some of the firms still follow the mass production system which is not suitable for producing the value added products according to customer needs. All these conditions can be easily met by using agile manufacturing system.

Approaches of Agile Manufacturing

There exists three approaches for agile manufacturing system as follows,

a) Rapid prototyping
b) Rapid tooling
c) Reverse engineering.

a) Rapid Prototyping : Rapid prototyping is an advanced technology that can be used for producing the physical models and create 3D-prototypes on the basis of the information collected from Computer Aided Design(CAD). Rapid Prototyping (RP) machines can fabricate complex materials into thin sheets on the basis of the computer model. These RP systems differs from milling machines which can draw complex parts from mixing the liquid, powder and sheet materials at one time.

b) Rapid Tooling : Rapid tooling is another approach to agile manufacturing which is divided into two types,

i) Additive Process : In additive process, rapid tooling works with the help of RP technology which is involved in producing moulds.

ii) Substractive Process : In substractive process, rapid tooling works with the help of milling machines.

c) Reverse Engineering : Reverse engineering includes huge number of approaches to produce a product or physical object with the help of the data from computer models.

Q22. What are the advantages of agile manufacturing.

Ans :

Agile manufacturing is flexible and provide a fast response to changing market trends, requirements of customers and to the actions of competitors. Agile manufacturing can also be termed as flexible manufacturing approach.

The advantages of agile manufacturing are,

1. Elimination of unnecessary inventory stock.
2. It provides great flexibility in scheduling production.
3. Reduces lead times.

Flexible manufacturing is defined as an improvement in hierarchical mass production methods. Agile can be defined as a process of fragmenting the use of production so as to produce customized products. Agile manufacturing requires organization wide view.

Integrated application environment is required by agile manufacturing so that a user can access the services easily. This integration extends the boundary of organization to include customers as well as suppliers. Agility is crucial in future and requires the following new manufacturing practices.

1. Companies should be able to form consortium quickly in order to produce new product using the concept of agile manufacturing.
2. Small-scale organization should use the computer networks to advertise about their manufacturing capabilities.
3. Intelligent procurement system need to be used by producer and suppliers to deliver the products fastly. This system reduces the costs, improves the accuracy and meets the customer demands on regular basis.

State the Conditions for Making Agile Enterprise Successful

There are various conditions which are required for making agile enterprise successful. They are,

1. Proper communication channel between the interacting parties.
2. Good sense of predictability. The goal of agile manufacturing organization includes providing customized products which can reduce the cost of manufacturing.
3. Introduction of new product in the market on time.
4. Providing better interactive relationship with customers.
5. Reconfigure the production process dynamically so as to include variations at the time of product design.

1.6 OPERATIONAL STRATEGY

Q23. What do you understand by operational strategy? Discuss the development of operational strategy.

Ans :

Operations Strategy

Each and every organization should consider the factors which are related to both internal and external environment and develop an operations strategies that can achieve "Business strategy and corporate mission". Operations strategies are directly derived from both business strategy and corporate mission.

Development of Operations Strategy

The development of operations strategy is depicted below :

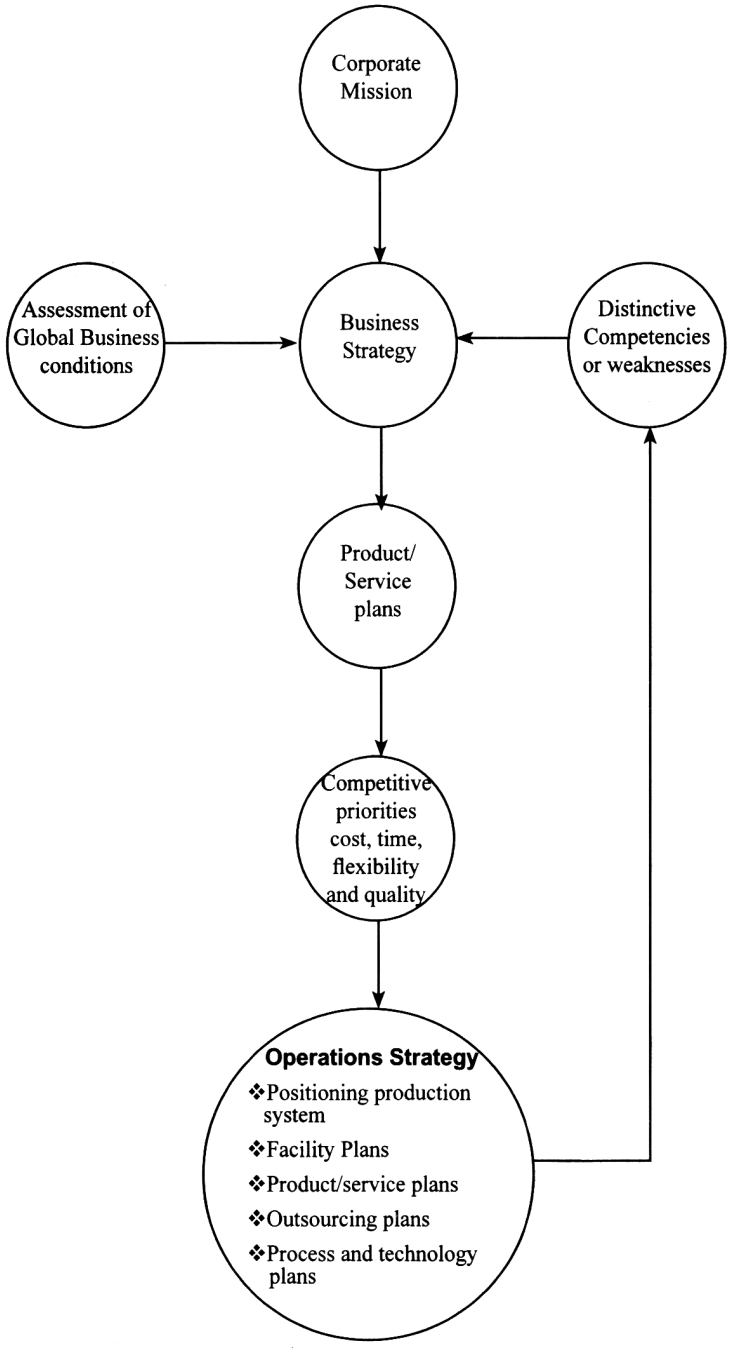


Fig.: Development of Operations Strategy

1. Corporate Mission

A corporate mission includes a set of long term goals/objectives which are distinctive to each and every company and includes the statements regarding the type of business. The organization wants

to be in the type of customers it wants to have, its beliefs regarding business and its objectives regarding survival, growth and profits.

2. Business Strategy

Business strategy is a long term plan of an organization which provides a route to achieve the corporate mission. Business strategies are incorporated in the organizations plan which includes a separate plan for all functional areas of business like marketing, finance and production/operations.

3. Global Business Condition

The factors such as analysis of markets, economic, social, technological and political developments and analysis of competition in the markets are included in the Global Business conditions.

4. Distinctive Competencies or Weaknesses

It exhibits huge competitive advantages and disadvantages in occupying the markets and also includes the things such as computerized production technology, dedicated and skilled workers, ability to bring new products into production quickly, exhausted production equipment or talented sales force. While forming business strategy, the main focus will be on identifying ways to finance distinctive competencies of an organization and develop the new strategies in order to increase the share in the market.

5. Competitive Priorities

Competitive Priority	Definition	Some way to Create Priority
Low Production Costs	The cost of each product/service which comprises of labour, material and overhead costs.	❖ New Technology ❖ Redesigning the product/service. ❖ Rise in rates of production. ❖ Decrease in stock ❖ Decrease in scrap or wastage
Performance of delivery	Fast delivery	❖ Large finished goods stock. ❖ Production rates are faster. ❖ Shipping methods are fast.
	On-time delivery	❖ Realistic promises ❖ Better information systems ❖ Better control on orders of production
High-quality products/services	Degree of excellence perceived by customer is shown by products/services.	**Improve product/service:** ❖ Appearance ❖ After-sales service ❖ Performance and functioning
Customer service and flexibility	Manufacturer should have an ability to change the production to other products/services, customer responsiveness.	❖ Change the type of process used. ❖ Use the advanced technologies. ❖ Increase the capacity.

Business strategy ascertain the combination of these priorities which are suitable for each product/service.

When the competitive priorities are decided for a product or service, operation strategy must ascertain the required production system required to assign the priorities for the product or service.

6. Operating Strategy

It is a long term plan for the production of company's products/services and also provides a way for the production or operations functions to achieve business strategies.

Operating strategies comprises of the decisions regarding the issues like the development of new products/ services and their introduction into production, requirement of new facilities and when such facilities are required, development of new technologies and processes and when they are required and which production schemes should be followed in order to produce/ manufacture products or services. A better understanding of competitive priorities facilitates to know the wide scope of operations strategy.

Q24. Explain the various elements of operations strategy.

Ans :

The elements of operations strategy are as follows,

1. Positioning the production system.
2. Product/service plans
3. Outsourcing plans
4. Process and technology plans
5. Strategic allocation of resources
6. Facility plans.

1. Positioning the Production System

Positioning the production system refers to the process of selecting following aspects for each product group of business strategy.

i) Type of product design

ii) Production processing system and

iii) Finished goods inventory policy.

i) Product Design : Product design is further classified into two i.e., custom product and standard product.

a) Custom products are designed based on individual customer needs. For example, Luxury Cruise Ship, Super computer etc.

b) Standard products are the products that are produced either continuously or in large batches. For example, Television etc.

ii) Production Processing System : This system is classified into two types, product-focussed system and process-focussed system.

a) Product-focussed production is also known as line flow production, production lines and assembly lines. Here, machines and workers must produce a product that is grouped together. It is suitable only for few standard products with high volume.

b) The process focussed production is best when the requirement is to produce unique products with minimum quantity.

iii) Finished-Goods Inventory Policies : The finished goods inventory policies are classified into two types. They are produce-to-stock and produce-to-order policies.

a) In produce-to-stock policy, the products are produced before time and kept in inventory. The products from inventory are sent as soon as the orders for the products are received.

b) In produce-to-order policy, the operations managers may not start producing the product until or unless they receive any orders from customers. In case if fast delivery of products is required then produce-to-stock is generally chosen as the products can be delivered directly from finished-goods inventory.

For example 'McDonald's' uses a produce-to-stock policy and 'Burger King' uses a produce-to-order policy.

As soon as the type of product design, production process and finished-goods inventory policy are selected for a product, the required structure of the production system is developed.

2. Product/Service Plans

A business strategy includes plan for new products and services which are to be designed, developed and introduced. Generally, the operations strategy is affected by product/ service plans because of the following reasons,

i) When products are designed, the complete features of each product are developed.

ii) When individual product feature directly influences how the product can be made or produced.

iii) When how a product is produced influences the design of the production system. The design of production system forms an important part of operations strategy.

3. Outsourcing Plans

Outsourcing plan (i.e., the amount of work to be outsourced) is an essential part of operations strategy. Outsourcing also signified hiring out some work which is supposed to be done by the company. Most of the companies make efforts to identify the top level of outsourcing to attain operations and business goals.

Now-a-days, companies are outsourcing few service functions like payroll, billing, order processing, developing and maintaining a website, recruiting capable employees, facility maintenance and computer maintenance.

1.7 Process Design - Project, Job, Batch, Assemble and Continuous

Q25. What is process design ? and discuss the various types of process design.

Ans : **(Feb.-21, Nov.-20, Dec.-19, Dec.-18, June-18, Imp.)**

Process design is concerned with the overall sequence of operations required to achieve the product specifications. It specifies the type of work stations that are to be used, the machines and equipment necessary and the quantities in which each are required.

The sequence of operations in the manufacturing process is determined by

1. The nature of the product
2. The materials used
3. The quantities being produced
4. The existing physical layout of the plant

Types of Process

a) Project Process
b) Job Process
c) Batch Process
d) Assemble Process
e) Continuous Process

A) Project Process

The project process is featured by high level of customisation of job, greater scope for project and the necessity of the substantial resources for the project completion.

Example

Construction of dams, factories, hospitals, development of new products and so on.

The projects are usually sophisticated in nature and involves greater time for completing and include greater number of difficult activities.

Features

The various features of project are,

1. A project has both the start and the end points. It is a separate entity.
2. Project is a non-repetitive task and not a permanent entity.
3. These tasks can be broken into recognized activities which need resources and times for their implementation.
4. It needs to be completed on a specified date.
5. The objectives and the output are clear and definite.

6. They are complex in nature and involve a time period of at least 2 to 3 years or 6 months or few projects may also have time duration of 10 years.
7. Huge investment is needed.
8. The project consists and its completion are always subjected to few risks and uncertainties.
9. A project consists of three phases (i.e.,) planning, scheduling and controlling and these phases make use of the two techniques known as PERT (Project Evaluation and Review Technique) and CPM Critical Path Method)
10. The PERT projects are launching/introducing a new product in the market research and development of a new war weapon, launching the satellite and so on. The examples of CPM projects are construction of roads, bridges, buildings etc.

Advantages

The various advantages of the project are,

1. The project management is useful in scheduling the production system.
2. Various network models are helpful in scheduling complex projects.
3. Various techniques of project management are useful in ascertaining the probability of completing the project on or before deadline.
4. The project management techniques are also used to determine the time period which is required to complete the project.
5. Project helps in designing and marketing the new product efficiently.
6. The corporate merger can be also carried out easily with the help of project management.
7. Long term planning of projects can be done effectively.
8. The delays in the job are reduced.

Disadvantages

The various disadvantages of the project management are as follows,

1. As the projects consist of various activities, and make use of different techniques, the time duration of each activity can be determined, but there exist several projects for which it may not be applicable.
2. It is assumed that the durations of activity are independent which may not be always possible.
3. During the project scheduling, several resources are required such as equipment, manpower and money, but these resources are limited which would result into several problems.
4. The estimation costs are very high.
5. The variable costs involved are also high.
6. The scheduling of the project is complex and is subjected to various variations.
7. The project process is difficult to plan and control resources, cost and time of completion.

B) Job Process

The job shop production system deals with producing the products for fulfilling the customer needs or requirements. In this system, all the orders need different processes and different sequences of technological order.

Objective

The main objective of job shop production system is to fulfill the requirements of customer's orders.

Characteristics

The different characteristics of job-shop production system are as follows,

1. The job shop production system helps in producing several different jobs in small batches.
2. In the job shop production system, a single complete unit is produced with the help of group of operators and processes according to the orders of the customers.
3. The product which is manufactured in job shop production system is costly and non-standardized. Example: Electric power plant,

dams construction, machine shop, sheet metal etc.

4. Job shop production system assembles equipments and machines at one place for huge objects.
5. In the job shop production system, general purpose equipments are used which helps in producing various jobs by using the same machinery.
6. In the job shop system, the material in process follows different patterns of processing in batches with the help of shop facilities.
7. In the job shop system, the job moves through various routes based on the work which has to be done.
8. A job shop system has to be managed by highly skilled workers.

Advantages

The following are the advantages of job-shop-production,

1. The job shop production system requires small amount of investment in equipments and machinery.
2. It is flexible in nature.
3. In the job shop system, a mistake or defect in one operation, does not interrupts the whole process.
4. It involves less managerial problems.
5. It can be started easily.
6. The risk involved is less, and the chances of failure are also less.

Disadvantages

Job shop system has the following disadvantages,

1. The production system of job shoo system is very complicated.
2. It needs an elaborate schedule of activities.
3. The job shop system faces difficulty in loading the machines.
4. It requires high inventories
5. The cost of material handling involved in job shop system is high.
6. Highly skilled machine operators are needed for managing the job shop system.
7. There are unbalanced work loads in job shop system.
8. As the raw materials are purchased on the basis of the order, its cost is high.

C) Batch Process

According to American Production and Inventory Control Society (APCS), batch production is defined "as a form of manufacturing in which the job passes through the functional departments in lots or batches and each lot may have a different routing".

Batch production includes producing specified number of products from time to time and keeping the goods ready in the inventory for sales.

Characteristics

Following are the situations wherein batch production system is used,

1. In case of short production runs.
2. When there is greater flexibility in plant and machinery.
3. When cost and lead time of manufacturing are less when compared to job order production.
4. When plant and machinery i.e., already set up is used for manufacturing the item in a batch and any modification is required for processing the next batch.

Advantages

Batch production consists of the following advantages,

1. Plant and machinery are optimally utilized.
2. Promotion and development of functional specialization.
3. When compared to job order production, cost per unit in batch production is less.

4. In batch production investment in plant and machinery is also low.
5. Batch production is flexible in nature to follow any process and number of products.
6. Operators enjoy greater job satisfaction.

Limitations

Along with advantages, batch production also suffers from some limitations,

1. In batch production, due to irregular and longer flows, material handling is difficult.
2. Production planning and control is also complicated in batch production.
3. Due to repetitive modifications in set up, it results into higher set up costs.
4. In batch production, work in process inventory is higher when compared to continuous production.

D) Assembly Process

When different parts or assemblies are manufactured with the help of a continuous process, then it is known as mass production. Usually the machines are organized in lines in the mass production.

In this type of production, machines are organized in the form of a line or product layout and it involves a very large volume of production. Mass production includes both product and process standardization and similar path is followed by all outputs.

Characteristics

Following are the situations wherein mass production is used,

1. In sequencing the product and process standardization.
2. Where production is carried out in large volumes.
3. Where the cycle time of production is short.
4. Where the special purpose machines are used which have the higher production capacities and output rates.
5. Where process inventory is less.
6. Where production lines are perfectly balanced.
7. Where materials, components and parts have continuous flow without any backward movement.
8. Where production planning and control is easier to deal with.
9. Where material handling is carried out automatically.

Advantages

Mass production holds the following advantages,

1. The rate of production is high in mass production with less cycle time.
2. Proper utilization of the capacity with the help of line balancing.
3. Mass production does not require high skilled workers, it can be carried out with the help of semiskilled or low skilled operators or workers.
4. Less process inventory.
5. Less manufacturing cost per unit.

Limitations

Besides having several advantages, mass production also suffers from few limitations

1. If one machine stops functioning, then the entire or complete or whole production line would be halt.
2. Alteration in the product design would drastically alter the line layout.
3. Greater investment in production facilities.
4. In mass production, the cycle time is ascertained with the help of the slowest operation.

E) Continuous Process

Continuous production system deals with continuous physical flow of materials. It is used when the product has fast consumption rate and has continuous demand.

Example : Petrol, Chemicals, Electricity etc.

Characteristics

The following are the characteristics of continuous production system.

1. In the continuous production system, the products passes through the same process.
2. The handling of material is done automatically in continuous production system.
3. In the continuous production system, the layout of the plant is designed on the basis of the production requirements.
4. Sophisticated control methods are used for measuring and controlling the inputs and outputs.
5. Proper maintenance of plants and effective control of quality are the prerequisites of continuous production system.

Advantages

1. In continuous production system, the production planning and control is simple when compared to job or batch production.
2. It makes use of specialized machines and procedures for standardizing the items in large quantities.
3. In the continuous production system, if the management takes the decision for discontinuing a particular line, then same machinery can be used for manufacturing other article.
4. The material handling is minimized in continuous production system.
5. The machine resetting involves very less time in continuous production system.
6. There is balanced flow of work in the continuous production system.
7. Continuous production system helps in providing lowest production cost per unit.

Disadvantages

The following are the disadvantages of continuous production system,

1. The effective working of continuous production systems depends on effective plant maintenance and effective quality control.
2. In continuous production system, the managers has to spend significant efforts for the planning before starting the production.
3. As continuous production system makes use of specialized machines, the amount of investment spent on these machines are very high.

1.7.1 Factors effecting Process Design Decisions

Q26. What are the major factors effecting process design decisions.

Ans : **(Dec.-19, Dec.-18, Imp.)**

Operations managers generally make process-design decisions after taking into consideration several factors. Some of these factors are :

1. Nature of demand
2. Degree of vertical integration
3. Flexibility
4. Degree of automation
5. Quality level and degree of customer contact.

A brief description of each of these factors and their influence on the process design decisions of an organization are given below.

1. Nature of Demand

The main objective of any production system is to produce products or services, according to customer requirements. Therefore, it is essential for an organization to schedule its production in such a way that it can always meet estimated future demand levels.

a. Influence of demand patterns : The demand for a product does not follow a fixed pattern over time. The rise or fall of demand over time is influenced by several factors, such as seasonal fluctuations, which affect the design of the production process of the product.

b. Influence of price level : In most countries, customers are price-sensitive in their purchases. They buy more of a

product when the price is set low, but tend to buy lower volumes when the price level is set high.

2. Degree of Vertical Integration

One of the prime considerations of an operations manager when developing production-process designs is the level of vertical integration. Vertical integration refers to the extent to which the production and the distribution chain is brought under the ownership of the organization.

3. Flexibility

An organization is said to be flexible only when it responds quickly to changing customer needs or market conditions. Flexibility is essential for organizations to increase or maintain their market share. Flexibility can be broadly classified into two types: Product/service, flexibility and volume flexibility.

a. Product/service flexibility : Product/service flexibility is the ability of the production system to shift quickly from producing one product to another. Some business strategies call for the production of many custom-designed products/services, in small lots.

Product/service flexibility is required in such cases. To produce different products in small lots, in most cases, general-purpose equipment and multi-skilled employees are used. The employees have to be trained so that they can perform different types of jobs.

b. Volume flexibility : Volume flexibility is the ability to increase or decrease production volumes rapidly in response to external changes. Volume flexibility is necessary for organizations which manufacture products whose demand fluctuates, because it is not economical to maintain a high level of inventory of such products.

The production processes for such organizations must be designed such that increasing or decreasing production levels is easy. The equipment for such organizations should be designed to meet the production requirements that are close to the peak levels of demand.

4. Degree of Automation

In the past, automating production processes was very costly. It was also difficult to integrate automated processes with other production processes. For these reasons, managers in the past tended to avoid automation. But, today, operations managers have realized that if automation is not made a strategic weapon, it will be a strategic limitation for their operations. Automation has become essential for organizations to become or remain competitive.

5. Quality Level and Degree of Customer Contact

The level of quality of a product or service decides whether it can compete in a market. Decisions taken on the desired quality level of products/services affect the design of the production process at all stages. The desired level of quality has a direct implication on the degree of automation to be built into the production process.

1.8 PRODUCTION PLANNING AND CONTROL (PPC)

Q27. Define PPC? What are the objectives of PPC?

Ans : **(Aug.-21, Aug.-19, Imp.)**

Production planning and control is a predetermined process which includes the use of human resource, raw materials, machines etc. PPC is the technique to plan each and every step in a long series of separate operation. It helps to take the right decision at the right time and at the right place to achieve maximum efficiency.

Objectives of Production Planning & Control

The objectives of PPC are as follows :

1. To ensure safe and economical production process

2. To effectively utilize plant to maximize productivity
3. To maximize efficiency by proper coordination in production process
4. To ensure proper delivery of goods
5. To place the right man for the right job, at right time for right wages.
6. To minimize labor turnover
7. To reduce the waiting time

Q28. What are the various elements of production planning and control.

Ans :

The following are main elements of Production Planning and Control.

1. Routing
2. Loading
3. Scheduling
4. Dispatching
5. Follow up
6. Inspection
7. Corrective

1. Routing

It is about selection of path or route through which raw materials pass in order to make it into a finished product. The points to be noted while routing process are – full capacity of machines, economical and short route and availability of alternate routing. Setting up time for the process for each stage of route is to be fixed. Once overall sequence are fixed, then the standard time of operations are noted using work measurement technique.

2. Loading and scheduling

Loading and Scheduling are concerned with preparation of workloads and fixing of starting and completing date of each operation. On the basis of the performance of each machine, loading and scheduling tasks are completed.

3. Dispatching

Dispatching is the routine of setting productive activities in motion through the release of orders and instructions, in accordance with previously planned time and sequence, embodied in route sheet and schedule charts. It is here the orders are released.

4. Expediting/Follow-up

It is a control tool which brings an idea on breaking up, delay, rectifying error etc., during the progress of work.

5. Inspection

Inspection is to find out the quality of executed work process.

6. Corrective

At evaluation process, a thorough analysis is done and corrective measures are taken in the weaker spots.

Q29. Explain the stages of production planning and control.

Ans : **(Jan.-18)**

Production Planning & Control is done in three stages namely,

1. Pre-planning
2. Planning
3. Control.

Stage 1: Pre-Planning

Under this phase of production planning, basic ground work on the product design, layout design and work flow are prepared. The operations relating to the availability scope and capacity of men, money materials, machines, time are estimated.

Stage 2: Planning

This is a phase where a complete analysis on routing, estimating and scheduling is done. It also tries to find out the areas of concern for short time and long time so that prominent planning can be prepared.

Stage 3: Control

Under this phase, the functions included are dispatching, follow up, inspection and evaluation. It tries to analyze the expedition of work in progress. This is one of the important phases of the Production Planning and Control.

1.8.1 Functions of PPC

Q30. What are the functions of PPC ?

Ans : **(Sep.-22, Aug.-21, Jan.-18, Imp.)**

The following figure depicts the functions of production, planning and control,

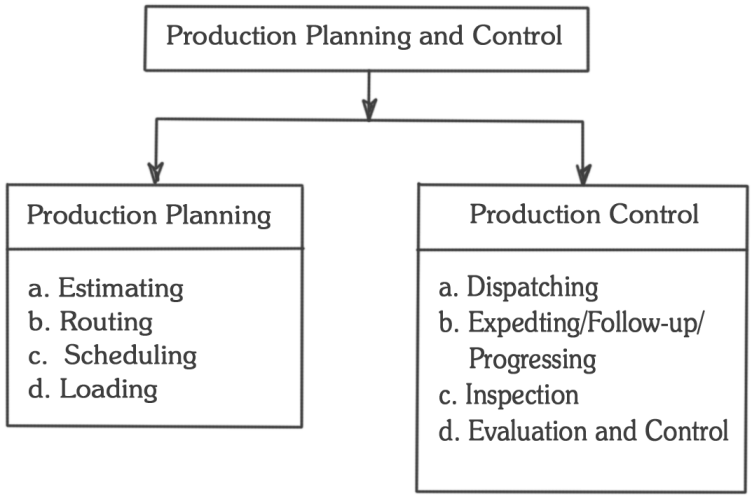


Fig.: Functions of Production Planning and Control

Production Planning Functions

The following are the main functions of production planning,

(a) Estimating

Estimating includes taking up the decisions about the quantity of goods which are to be produced and the level of cost in producing a product on the basis of sales forecast. It includes assessing the personal capacity of the machine and materials required in order to meet the target of planned production before the budgeting is done for resources.

(b) Routing

It is the process of deciding the order of operations to be carried out during the production process. It ascertains as to-what work should be carried out? How these operations will be performed? And where these operations would be performed?. It's main objective is the selection of best and cheapest way to perform a job.

(c) Scheduling

It includes giving priorities to different jobs and ascertaining the starting and finishing time of each operation/activity. Scheduling basically is the preparation of time-based schedule which shows the time and rate of production. The two main objectives of scheduling are to avoid unbalanced use of time between different work centres and departments and optimum utilization of the labour.

(d) Loading

Machine loading is performed along with routing to ensure smooth workflow while fixing the loads to different machines, jobs priority and machine capacities are considered. Scheduling enables the firm to be aware of the delivery dates for the production of parts, sub-assemblies and finished products. It is also used to maintain uniform load on different work centers and machines. Scheduling provides the manufacturing time table for products.

Production Control Functions

The following are the production control functions,

(a) Dispatching

It is related to the actual performance of work through planning process where the instructions are delivered as per the schedule, sequences shown in the route sheets and machine loading schedules.

(b) Expediting/Follow-up/Progressing

Keeping a track on the production activities for ensuring that the activities are performed as per the schedule is known as expediting. It follows dispatching function. It maintains continuous contact with the manufacturing centers to provide a feedback to PPC manager which helps him in reviewing the schedule and targets to be achieved.

(c) Inspection

It constitutes checking the quality of production process and analyzing the effectiveness of processes, methods and workers, so that desired quality can be achieved by making the necessary improvements.

(d) Evaluation and Control

The entire process of manufacturing is evaluated to make the necessary improvements wherever they are required. Control of various activities like waste reduction, value analysis, inventory control and optimal exploitation of resources so as to reduce manufacturing cost.

Q31. What are the requirements, advantages and limitations of production planning and control?

Ans : **(Aug.-19)**

Requirements of Effective PPC

Some of the requirements for effective PPC are,

1. Robust and effective organization structure with appropriate delegation of authority and responsibility at different levels in the organization.
2. Information feedback system should make a provision of detailed and latest information about the individuals dealing with PPC functions.
3. Experienced and trained personnel are required for utilizing the special tools, equipments and manufacturing processes.
4. Should be flexible in nature to face any changes or challenges or problems if any such as materials scarcity, power failures, breakdown of machinery, employees absenteeism.
5. Presence of adequate management policies for the inventory and production levels, product mix and inventory turnover.
6. Standardizing materials, tools, machinery, labour, quality, equipments etc.
7. Requires accurate determination and exact evaluation of lead times for the manufacturing and procurement processes.
8. Adequate plant capacity in order to meet the demand. The plant should be flexible enough to react to the introduction of new products, variations in product-mix and rate of production.

Advantages of PPC

The various advantages of PPC are,

1. Production planning and control is one of the most important functions of operations management and is considered as the heart of operations management which co-ordinates different stages of production.
2. Effective and efficient production planning and control leads to optimum utilization of resources, best quality, less manufacturing cycle time, lower inventories, quick and easy delivery, lesser production costs, lesser amount of capital investment, better customer service and greater customer satisfaction.
3. With the efficient utilization of resources PPC leads to increase in productivity, economical production on time and production of correct quality.

4. Productive PPC helps the firm to increase its total returns, market share and profitability and also helps the firm in facing the competition.

Disadvantages/Limitations of PPC

Some of the disadvantages of PPC are,

1. PPC functions depend upon few assumptions and beliefs which are imaginary and not realistic in nature such as the customer's demand, plant capacity, availability of materials, power, equipments etc. If these assumptions fail then PPC would turn out to be unproductive.
2. Employees may oppose the changes in production levels which are set according to the production plans if such plans are constant.
3. PPC is a time consuming process, especially when routing and scheduling functions are supposed to be carried out for sophisticated and large products.
4. PPC turns out to be extremely impossible to manage the changes in environmental factors which take place due to instant changes in technology, changes in customer tastes and preferences about latest fashion, government rules and regulations altering quickly and several times, shortage of power supply by electricity boards, break in supply chain because of natural calamities like floods, earth quakes, war and so on.

1.9 Interface of Product Life Cycle and Process Life Cycle

Q32. Explain the various stages of product life cycle.

Ans : **(Dec.-19, Dec.-18, Imp.)**

The product life cycle has 4 very clearly defined stages, each with its own characteristics that mean different things for business that are trying to manage the life cycle of their particular products.

1. Introduction Stage

This stage of the cycle could be the most expensive for a company launching a new product. The size of the market for the product is small, which means sales are low, although they will be increasing. On the other hand, the cost of things like research and development, consumer testing, and the marketing needed to launch the product can be very high, especially if it's a competitive sector.

Fig.: Product Life Cycle Stages

2. Growth Stage

The growth stage is typically characterized by a strong growth in sales and profits, and because the company can start to benefit from economies of scale in production, the profit margins, as well as the overall amount of profit, will increase. This makes it possible for businesses to invest more money in the promotional activity to maximize the potential of this growth stage.

3. Maturity Stage

During the maturity stage, the product is established and the aim for the manufacturer is now to maintain the market share they have built up. This is probably the most competitive time for most products and businesses need to invest wisely in any marketing they undertake. They also need to consider any product modifications or improvements to the production process which might give them a competitive advantage.

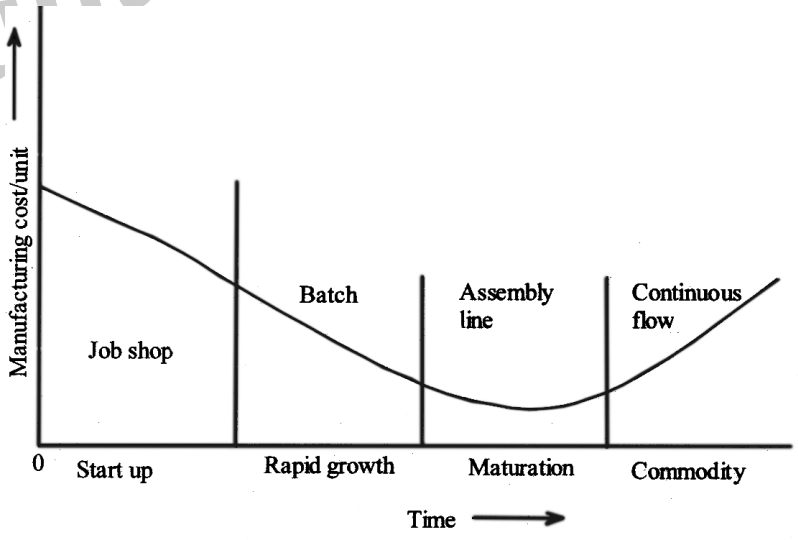
4. Decline Stage

Eventually, the market for a product will start to shrink, and this is what's known as the decline stage. This shrinkage could be due to the market becoming saturated (i.e. all the customers who will buy the product have already purchased it), or because the consumers are switching to a different type of product. While this decline may be inevitable, it may still be possible for companies to make some profit by switching to less-expensive production methods and cheaper markets.

Q33. Explain the various stages of process life cycle.

Ans : **(Dec.-19, Dec.-18, Im.)**

Process technologies involves various life cycles which are related to the product life cycles. Right from the start up stage to the decline stage, the processes change in organization with regard to the volume, rates of process innovation and automation. Job shop technology is used in start-up and moves towards the continuous flow technology, if incase the exists to turn out into a product commodity. During the start up stage, the throughput volumes and automation are low but are high during the maturation and decline stage.



Process technology refers to the process which includes the equipment, people and systems that are being used to manufacture the products and services of the firm. During product development, four technologies are used at different stages. They are job shop, batch, assembly line and continuous.

1. Job Shop Technology

It is used in the start up stage of process life cycle as it is suitable for producing small batches of variety of products wherein each product is designed conventionally and ultimately needs its own unique set of processing steps which are to be carried out through the complete production process.

2. Batch Technology

It is used in second stage of process life cycle. It is used in rapid growth stage because batch facilities are best suitable in situations wherein wide range of products, are demanded again and again and in large volumes. Batch technology is suitable to produce a wide range of products in wide variety of volumes.

3. Assembly Line Technology

It is used in the maturation stage as it helps in producing limited range of standardized products in high volume.

At this stage of process life cycle, product designs are comparatively stable and advanced equipment, experienced human skills and management systems are developed and focused upon the limited range of products and volumes.

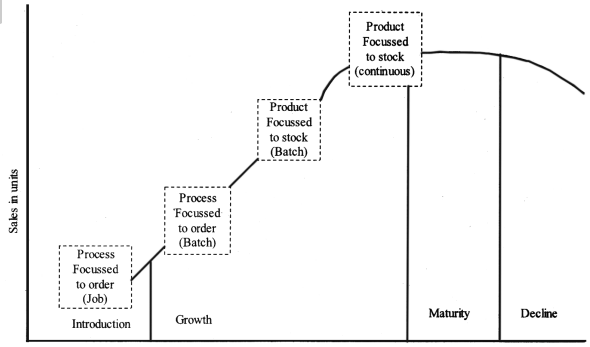
4. Continuous Flow Technology

It is used when product turns into a commodity in process life cycle. In this stage, the products and materials are produced in continuous and endless flow manner. In this stage, products become highly standardized with the help of continuous flow technology which provides a high volume continuous operation with capital intensive specialized automation".

Q34. State the relationship between product life cycle and process life cycle?

Ans : **(June-18)**

As the product develops and passes through different stages on life cycle, the productive system also passes through its ovmdife cycle from job-shop system (or process focussed system to order,) when the product passes from initial stages to intermediate stages to a continuous system when the demand of the product is high.



The different stages of product and process development are dependent on each other. The productive system depends on the product volume which is sold, the product volume which is sold depends on the costs and price related to the competitive position of quality and this costs and price depends on the use of effective productive system. The factors used in the productive system helps in decreasing the costs and are essential elements of the competitive strategies of the manager. The reduction in costs can be useful for aggressive pricing which helps in developing market share, building experience etc. process life cycle is developed by using various levels of process technology at each development stage. The process technology should show the need for flexibility when there are low volume dealing with wide varieties in the product design.

Short Question and Answers

1. Operation management

Ans :

Introduction

Operation management is the management of systems or processes that create goods and/or provide services.

Operations management is a modern discipline which deals with the process of planning, designing, operating and managing the systems and subsystems of an organization for the achievement of organizational goals.

Definition

Operation management can be defined as "the branch of management that studies all the processes and systems that are undertaken for converting inputs into value added outputs".

According to the U.S Department of Education, "Operations management is the field concerned with managing and directing the physical and/or technical functions of a firm or organization particularly those relating to development, production and manufacturing".

2. Objectives of Operations Management.

Ans :

i) To provide customer service

The main objective of any operating management systems is to utilize resources judiciously for the satisfaction of customer needs and wants. Therefore, customer satisfaction is a key objective of operations management. Operation management focuses on providing the right products at a right price at the right time. Hence, this objective will influence the operations manager's decisions to achieve the required customer service.

ii) Effective utilization of resources

Resources that are used in the business organisation must be carefully utilized. Inefficient use of resources or inadequate customer service leads to commercial failure of an organisation. Operations management is concerned essentially with the utilization of resources. It aims at obtaining maximum output from the available resources with minimum cost.

iii) To reduce cost of production

Operation management aims at reduction in the cost of production of goods and services. The cost per unit of the product has to be set properly and all efforts should be taken to control the actual cost to pre-determined cost of production. Cost can be classified in to fixed cost and variable cost. The variable cost changes with every level of production. This variable cost can be checked by means of inventory and labour control techniques.

3. Define casting

Ans :

Casting is the process for obtaining desired component by pouring molten metal in the mould cavity and allowing it to solidify.

Steps Involved in Casting

The various steps involved in making a casting are as follows,

i) Pattern preparation

ii) Moulding

iii) Melting and pouring the metal

iv) Solidification

v) Removal of casting and feeling

vi) Machining

vii) Heat treatment

viii) Finishing.

4. Shearing extrusion.

Ans :

The concept of shearing extrusion consist of the following features,

i) Any cross-sectional shape can be extruded from the non-ferrous metal.

ii) So extrusions can offer savings in both metal and weight.

iii) Cross-sectional shapes are not possible by rolling.

iv) A lot of time is lost when changing of shapes takes place. Since, the dies may be readily removed and replaced.

v) Dimensional accuracy of extruded parts is generally superior to that of rolled ones.

vi) The range of extruded items is very wide and rods from 3 to 250 mm in diameter, pipes of 20 to 400 mm in diameter and wall thickness of 1 mm and above contains more complicated shapes which cannot be obtained by other mechanical working methods.

vii) Very large reductions are possible as compared to rolling, for which the reduction per pass is < 2.

viii) Automation of extrusion is simpler as items are produced in a single passing.

5. Heat treatment

Ans :

"A combination of heating and cooling operations timed and applied to a metal or an alloy in the solid state to produce desired properties" is known as heat treatment. Heat treatment involves transformation or decomposition of austenite and the products obtained will determine the physical and mechanical properties. Heat treatment of steel involves, heating the material to a temperature above the critical range to form austenite. Heat treatment depends on,

- The temperature to which the material is heated.
- Rate of cooling.

6. Define agile manufacturing.

Ans :

Agile manufacturing is a method of manufacturing system which is entirely different from that of the lean manufacturing. Unlike lean manufacturing, it is used for the products whose production cannot be controlled.

Agility is the capacity to change the ideology according to the changing conditions or flexibility in the methods according to the rapid changing environment. Agile manufacturing is defined as a flexible manufacturing method which is being used to produce goods and services in order to meet the changing customer's needs and expectations quickly and effectively. The change in manufacturing system from mass production to agile manufacturing is due to following reasons,

a) Increase in competition across the world

b) Market fragmentation

c) Increased cooperation among the companies

d) Growing needs and expectations of customers

e) Reduction in product life cycle time, lead time and development time

f) Increased focus on customers.

The change in manufacturing towards the production of products or services with (less) reduced lead times results in number of problems of inventory, efficiency of plant, overhead and so on. Some of the firms still follow the mass production system which is not suitable for producing the value added products according to customer needs. All these conditions can be easily met by using agile manufacturing system.

7. Job Process

Ans :

The job shop production system deals with producing the products for fulfilling the customer needs or requirements. In this system, all the orders need different processes and different sequences of technological order.

Objective

The main objective of job shop production system is to fulfill the requirements of customer's orders.

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Ans :

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6. Where production lines are perfectly balanced.
7. Where materials, components and parts have continuous flow without any backward movement.
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9. Where material handling is carried out automatically.

10. Production Planning and Control (PPC)

Ans :

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Objectives of Production Planning & Control

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2. To effectively utilize plant to maximize productivity
3. To maximize efficiency by proper coordination in production process
4. To ensure proper delivery of goods
5. To place the right man for the right job, at right time for right wages.
6. To minimize labor turnover
7. To reduce the waiting time.

Choose the Correct Answers

1. The long term decisions included in the scope of operations management are, [d]
   (a) Facility location (b) Plant layout design
   (c) Capacity planning (d) All the above
2. The primary objectives of production department are, [c]
   (a) Cost reduction (b) Quality improvement
   (c) Both (a) and (b) (d) Material management
3. The process applied for producing average volume of moderate variety of goods and services is, [a]
   (a) Batch process (b) Job shop process
   (c) Project process (d) Continuous process
4. The major process decisions considered by production/operations manager are, [d]
   (a) Capital intensity (b) Customer involvement
   (c) Resource flexibility (d) All the above
5. is _____ necessary to observe the performance of transformation process. [b]
   (a) Transformation mechanism (b) Feedback mechanism
   (c) Performance mechanism (d) None of the above
6. The development of operations involves, [d]
   (a) Business strategy (b) Corporate mission
   (c) Competitive priorities (d) All the above
7. The different techniques of PPC are, [d]
   (a) Aggregate planning (b) Make or Buy decisions
   (c) Process layout (d) Both (a) and (b)
8. _____ involves the important decision about how to make the optimum utilization of the resources. [a]
   (a) Capacity planning (b) Aggregate planning
   (c) Production planning (d) Material planning
9. The process in which two pieces to be joined are overlapped and placed between two pointed electrodes _____. [a]
   (a) Spot welding (b) Resistance welding
   (c) Projection welding (d) Seam welding
10. During solidification of metal casting, compensation for solid contraction is, [d]
   (a) Made by providing chills (b) Provided by over size pattern
   (c) Achieved by properly placed riser (d) Obtained by promoting directional solidifications

Fill in the blanks

1. _____ is the branch of management which studies all processes and systems undertaken to convert inputs into value added outputs.
2. _____ is flexible and provide a fast response to changing market trends, requirement of customers and to the actions of competitors.
3. When low volume of high variety goods are produced, _____ process is used.
4. Semi continuous process is also known as _____.
5. _____ refers to the active participation of customers in the production process.
6. _____ is an evaluation technique which involves charts used for analyzing and controlling product and services to satisfy delivery schedules.
7. The first phase of PPC in which firms are involved in forecasting the appropriate actions through which stated objectives can be achieved is _____.
8. _____ is defined as an orientation and harmonization of the organizations materials and facilities towards achievement of goals.
9. The process of joining two materials with the help of heat or pressure or by some other means is known as _____.
10. The products have fine grain structure with high density in _____ casting.

ANSWERS

1. Operation management
2. Agile manufacturing
3. Job shop
4. Repetitive process
5. Customer involvement
6. Line of Balance
7. Planning phase
8. Production planning and control
9. Centrifugal
10. Non conventional machining.

UNIT II

Long – range capacity Planning

Capacity Planning, Line Balancing, facility location and Facility layout. Service facility layout. Aggregate Planning: Aggregate Demand, criteria for selecting Aggregate Plans, Aggregate Plans for Service & mathematical Models for Aggregate Planning.

Master Production Scheduling: Objective, Procedure and Time frame.

Sequencing of Operations: n-Jobs with one, two and three facilities.

Maintenance Management: Repair Programmes, Break down, Preventive and Corrective maintenance. Maintenance issues in service organizations.

2.1 CAPACITY PLANNING

Q1. Define capacity. What are the factors influencing capacity.

Ans :

Capacity refers to the ability of a productive unit (may be a machine, equipment and labour) to produce outputs within a specified time period. However, capacity can also be related to the intensity with which a facility is used.

Factors Influencing Plant Capacity

The capacity or plant capacity is mainly influenced by,

1. The amount of capital which is required to be invested in the business.
2. The demand for a product or service in the market.
3. The extent of desired automation.
4. Integration levels (vertical and horizontal integration).
5. Selection of an appropriate technology.
6. The nature of factors influencing the determination of plant capacity which includes the modifications in product design, process technology, conditions prevailing in the market product life cycle and so on.
7. Problems occurring in forecasting future demand and technological forecast.
8. Both future demand and present demand over the short, intermediate and long range time horizons.

Q2. Define capacity planning. Explain the classification of capacity planning.

Ans :

Capacity Planning

Capacity planning deals with the estimation of both the long and short-term capacity requirements of a concern. It also provides different methods through which such requirements can be successfully fulfilled.

Capacity planning is the process of determining the production capacity needed by an organization to meet changing demands for its products. In the context of capacity planning, design capacity is the maximum amount of work that an organization is capable of completing in a given period.

Need for Capacity Planning

Capacity planning becomes essential :

1. If a company wants to bring improve-ments in its levels of production.
2. If the company decides to launch a new product in the market.

Once capacity requirements are determined the next step for a firm is to make decisions regarding the location of a facility and process technology.

Capacity Planning Decision

Capacity planning involves:

1. The estimation of the existing capacity.
2. Forecasting the future needs of capacity.

3. Determining the different ways through which capacity can be improved.
4. Assessing the economical, financial and technological alternatives related to capacity.
5. Selecting the most appropriate capacity alternatives for achieving the mission of the firm.

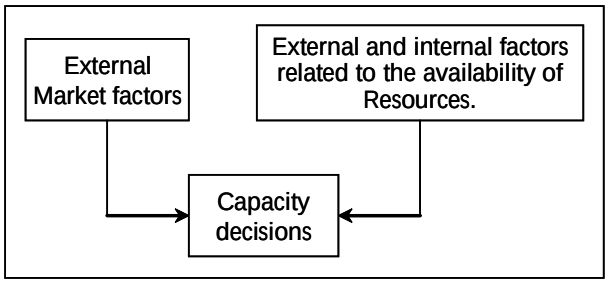


Fig.: Inputs to Capacity Decisions

Classification of Capacity Planning

The different types of capacity planning are explained as follows :

1. Long-term capacity strategies

It is difficult to predict the long term capacity requirements because the future demands are difficult to predict. Long-range capacity requirements are dependent on marketing plans, product development and life-cycle of the product. Long-term capacity planning is related with accommodating major changes that affect overall level of the output in long-term. Designing and implementing the long-term capacity plans are the major responsibilities of management. Following parameters will affect long-range capacity decisions.

- **Multiple Products:** The manufac-turing of multiple products will reduce the risk of failure. Production of a single product is always risky. If we produce multiple products, each products in different stages of their life cycles, it is easy to schedule them to get maximum capacity utilisation.
- **Phasing in Capacity:** The rate of obsolescence is high in the case of high technology industries compared to other types of industries. The products should be brought into the market quickly.
- **Phasing out Capacity:** The out-dated manufacturing facilities cause excessive plant closures. The impact of the closure will be huge in the case of industries. The phasing out also affects the employability of employees and which in turn affect the standard lining of the society. The phasing out options makes alternative arrangements for men like shifting them to other jobs or to other locations, compensating the employees etc.

2. Short-term capacity strategies

Another task in capacity planning is to develop short term capacity strategies. Managers can predict the future demand for the product in the near future based on statistical tools. Managers then compare requirements with existing capacity and then take decisions as to when the capacity adjustments are needed.

Fundamental capacity is fixed for short period. Major facilities will not be changed. Many short-term adjustments for increasing or decreasing capacity are possible. The adjustments to be required depend upon the conversion process like whether it is capital intensive or labour intensive or whether product can be stored as inventory. Capital-intensive processes depend on physical facilities, plant and equipment. Short-term capacity can be modified by operating these facilities more or less intensively than normal.

The short-term capacity strategies

The following are different types of short term capacity strategies**:**

1. **Inventories:** Stock of finished goods during slack periods to meet the demand during peak period.
2. **Backlog:** During peak periods, the willing customers are requested to wait and their orders are fulfilled after a peak demand period.
3. **Employment level:** Hire additional employees during peak demand period and lay off employees when demand decreases.

4. **Employee training:** Develop multi skilled employees through training so that they can be rotated among different jobs.

5. **Subcontracting:** During peak periods, hire the capacity of other firms temporarily to producethe component parts or products.

6. **Process design:** Change job contents by redesigning the job.

Q3. Explain the process of capacity planning.

Ans :

The process involved in capacity planning is as follows:

1. Demand forecasting

Capacity planning starts with the setting of up of a business plan which sets out the types of goods or services to be produced. The Manager has to take a long range forecast of demand in order to determine the resources needed to produce and offer specified goods and services. Market trend changes, competitor's role and technological changes have to be carefully examined.

2. Capacity decisions

The demand forecasting of goods and services then must be translated in to a measure of capacity needed. On the basis of forecasting of demand for products, organisation will be able to determine the various resources needed for producing such goods.

3. Facilities planning

Capacity decisions automatically lead to the setting up of necessary facilities in order to produce goods and services as determined the previous steps. Facility planning can be done either by the expansion or contraction of existing facilities or by setting up of additional new facilities.

4. Decisions and implementation

Finally, alternative resource requirements plan should be properly evaluated. The feasibility of plans along with its economic impact needs to be analysed. Detailed study of economic impact of resource requirements is essential to make the capacity planning a reality.

Q4. Explain the Importance of capacity planning.

Ans :

1. Capacity decisions have an impact on the ability of the organisation to meet future demands for products and Services.

2. Capacity decisions affect operating costs. It should be seen that capacity and demand requirements will be matched, which will tend to minimize operating costs. In practice, this is not always achieved because actual demand either differs from expected demand or tends to vary. In such cases, a decision might be made to attempt to balance the costs of over and under capacity.

3. Capacity is usually a major determinant of initial cost.

4. Capacity decisions often involve long-term commitment of funds.

5. Capacity decisions can affect competitiveness.

6. Capacity planning reduces the complexity in manufacturing operation.

Q5. What are the principles of capacity planning?

Ans :

The following are the principles for planning for the adequate capacity resources within an infrastructure.

1. Agree on a common definition of capacity planning

Capacity planning means different things to different people. Agreeing on a common, formal definition of the process is essential in designing and implementing an effective capacity planning program. Proper care should be taken in defining various concepts of capacity planning.

2. Select a capacity planning process owner

The next step is to select a suitable qualified individual to serve as the process owner. The person will be responsible for designing, implementing and maintaining the process

and will be empowered to negotiate and delegate with developers and other support groups.

3. **Identify the key resources to be measured**

Once the process is selected, the next task is to identify the infrastructure resources to be measured.

4. **Compare current utilisation to maximum capacities**

This principle aims to determine how much excess capacity is available for selected components. The utilisation or performance of each component measured should be compared to the maximum usable capacity.

Q6. Explain the Factors Affecting Capacity Planning.

Ans :

The major factors relate to

1. **Facilities :** Which includes as size and provision for expansion, transportation costs, distance to market, labour supply, energy sources, environmental factors such as heating, lighting, ventilation etc.
2. **Product and Services Factors :** The more uniform the output, there more opportunities there are for standardisation of methods and materials, which leads to greater capacity.
3. **Process Factors :** The quantity capability of a process output quality are also determinant of capacity.
4. **Human Factors :** Job specification, job description, training, experience, employee motivation etc., has lot of impact on output.
5. **Operational Factors :** Like inventory shortages, purchasing requirement quality, inspection, control procedures, etc., have an impact on effective capacity.
6. **Supply Chain Factors :** Forecasting the impact of changes on supplies, warehousing transportation, distribution etc., is taken into account in capacity planning.
7. **External Factors :** It includes quality standards performance standards, pollution standards on product and operating equipments, etc.

2.2 LINE BALANCING

Q7. What is line balancing? Explain the procedure of line balancing.

Ans :

Line Balancing is the process of sequential work activities into work stations in order to gain a high utilization of labour and equipment and thereby to reduce Idle time.

Line balancing is to arrange the production line so that, there is a smooth flow of production from one work station to another. It balances the flow of production in such a way that there is no delays at any work station which will result in idle time for the next work station.

The main aim line balancing is to minimize the idle time along the line and result in optimum utilization of production resources.

The process of deciding how to assign tasks to workstations is referred to as line balancing. The task are assigned in such a way that each assembly line or production have equal time requirement. This helps to minimize idle time and high utilization of human resource and machineries. Lines that are perfectly balanced will haves a smooth flow of work. The limitation of line balancing is that there are various jobs which do not have the same duration therefore it is difficult to group all the activities of production.

Line Balancing Procedure

The following are the steps involved in a line balancing procedure,

1. **Step 1**

Line balancing is initiated with the determination of cycle time and the theoretical minimum number of work stations. Both the parameters can be estimated by following a formula,

$$X_a = \frac{\Sigma a}{CT} = \frac{\text{Sum of all task time}}{\text{Cycle time}}$$

$$\text{Cycle time, } CT = \frac{\text{Time available}}{\text{Output needed}}$$

2. Step 2

After computing CT and 'X' the actual number of work stations (A) required can be calculated by rounding off the value of 'X' to the next higher integer value.

3. Step 3

As soon as the minimum number of workstations are computed, next step is to assign the tasks to different workstations starting from left to right.

4. Step 4

This step outlines the criteria used for deciding which task need to be assigned to which workstation. Anyone of the following criteria is used before assigning tasks to different workstations.

(i) The preceeding tasks need to be already al lotted in the sequence.

(ii) The time of task should not exceed the time which is left at different work-stations.

When the tasks are not suitable for a particular workstation then they must be proceeded to the next workstations.

5. Step 5

After assigning all the tasks to the respective workstations, the remaining time of an individual workstation can be obtained by deducting the sum of times taken for the allotment of tasks to the workstation from that of the cycle time.

6. Step 6

If a tie exists between the two tasks then anyone of the following rules is followed,

(i) The task which is haying the longest task time should be assigned first.

(ii) The task which is having the greatest number of followers should be assigned.

Even by following the above stated rules, still if there exist a tie then tasks need to be chosen arbitrarily.

7. Step 7

Tasks must be assigned continuously to all w orkstations until all workstations are occupied by atleast a single task.

8. Step 8

Finally, the percentage of idle time and the efficiency of line balancing is computed.

Q8. Explain the various methods of line balancing.

Ans :

1. Heuristic Method

Heuristics mean 'searching to find' i.e., find out things for oneself. It describes a particular approach to problem solving, decision making and control.

Heuristics are often simple 'Thumb rules' which are employed to solve complex problems. They utilize common sense, logic and past experiences.

These methods breakdown a problem into smaller and easily manageable subproblems. The most promising solution for each subproblem is determined.

Steps in Heuristic Method

i) Identify the work job.

ii) Breakdown the work into elemental tasks or steps.

iii) List the various steps with predecessor activities and duration.

iv) Sketch the precedence diagram.

v) Assume a cycle time or take the given cycle time. The maximum number of stations will be the number of tasks. The minimum will be total duration divided by cycle time. The aim is to balance the line with minimum number of stations.

vi) Assign tasks to stations as follows using any one of the methods.

a) Permutability of Tasks : It means that any number of tasks or steps of a column can be obtained to make up their total time closer to cycle time, provided their

total time does not exceed cycle time.

Tasks of even different columns can be combined, provided the precedence constraint is maintained. Analysis is carried out column by column and one can move to next column only after the tasks in previous column have been assigned to station.

b) Lateral Transferability of Tasks : For making total time of tasks equal to cycle time, tasks or steps may be shifted laterally provided the precedence relationships are maintained.

2. Linear Programming

It is another conventional method used for line balancing. This can be explained with the help of an example.

Example

A job has 3 elements whose duration is giving below :

Draw line of balance.			
Element	1	2	3
Predecessor	–	1	2
Time in seconds	6	4	5

Fig.: Network Diagram

Sol.:

Total time for the job = 15 seconds, consider the cycle time to be 5 seconds.

Then the number of stations is given by,

$$\text{Number of stations} = \frac{\text{Total time}}{\text{Cycle time}}$$

$$= \frac{15}{5} = 3$$

Maximum number of work stations = 3

Let us represent the inequalities constraints, namely constraints for cycle time and precedence constrains.

Assumptions

Let 'a' be the a^{th} element

where

a = 1, 2, 3, N

(where, a = 6)

b = Represent b^{th} workstation

Where,

b = 1, 2, 3 N

t_a = Time required to finish a^{th} element.

Decision variables x_{ab} equals to 1 if a is assigned to b workstation. Similarly X_{ab} would be zero, if 'a' is assigned to any other workstation other than 'b'.

(i) Cycle Time Constraints

It is represented by $\Sigma t_a x_{ab} \leq C$

Where,

C = Cycle time

$6x_{11} + 4x_{21} + 5x_{31} \leq 5$

$6x_{12} + 4x_{22} + 5x_{32} \leq 5$

$6x_{13} + 4x_{23} + 5x_{33} \leq 5$

(ii) Element (Task Constraints)

It represents that single element can be specifically assigned to only one particular workstation. It is given by,

$Ex_{ab} = 1$ where a is 1, 2, 3, ..., N (N = 3)

$x_{11} + x_{12} + x_{13} = 1$

$x_{21} + x_{22} + x_{23} = 1$

$x_{31} + x_{32} + x_{33} = 1$

(iii) Precedence Constraints

According to the precedence diagram, the element number 3 follows the element 2. Thus, $x_{31} \leq x_{21}$. If element 2 is assigned to the workstation-2 then the decision variable $x_{21} = 2$, and if element 3 isn't assigned to workstation 2, then $x_{31} = 0$.

Since $0 \leq 2$; $x_{31} \leq x_{21}$ is allowed other

relationships which can be written as,

$$x_{32} \leq x_{22} + x_{12}$$

This indicates that element 3 can be allocated to work station-3 only after the predecessor element 2 has been assigned to either first or second work station. Similarly the other relationships could be,

$$x_{33} \leq x_{11} + x_{12} + x_{13}$$

Objective Function

$$\text{Min } Z = 1(x_{21} + x_{31}) + 10\,(x_{23} + x_{33})$$

Where,

x_{21} = Allocation of 2nd element to workstation-1 and

x_{23} = Allocation of 2nd element to workstation-3.

3. Dynamic Programming

Dynamic or mathematical models are also existing for line balancing. However, such models have certain limitations because of which they can't be used much for solving line balancing problems. It uses a formula.

$$\frac{\text{Production time}}{\text{Cycle time}}$$

to obtain an objective function (minimum function).

4. Computerised Line Balancing

Due to increased complexity of line balancing problems, heuristics and other conventional methods are becoming incompetent with the existing situation. Under such circumstances, computer software packages can be used.

Q9. Explain the determination of line balancing ?

Ans :

1. Cycle Time

To ensure that work flows smoothly through process, each workstation needs to be given the same amount of time to complete its tasks on a particular unit. This is called the required cycle time or "pace".

Cycle time(C) is given by the formula

$$C = \frac{\text{Available time duration}}{\text{output units required in that duration}} \quad \ldots (1)$$

If the time required at any time station exceeds that which is available to a worker, then additional workstation need to be added.

2. Theoretical Minimum Number of Workers Required

For a desired rate when given cycle time, we can find out the theoretical minimum number of work centres '*n*' using.

$$n = \frac{T}{C} \quad \ldots (2)$$

Where n = Theoretical minimum number of work centres

T = Sum of all task times and

C = Cycle time for the desired output rate

Note : In calculations, we may get the value of '*n*' as a fraction. So, we found off the value to the next higher number and call that as the number of actual workers required, say, *N*.

3. Efficiency

The procedure for analysing line balancing problems involves

i) Determining the number of stations and time available to each station,

ii) Grouping the individual tasks into amounts of work at each station and

iii) Evaluating the efficiency of grouping.

When the available work time at any station exceeds of the cycle time (*t*) that which can be done by one work centre then additional centre must be added at that station. The key to efficient balancing is to group activities in such a way that the sum of individual work times at a centre is equal to or less than the cycle time. It can be multiple of cycle time also if corresponding numbers of work centres are added.

An efficient balancing is one which will minimize the idle time. The balance efficiency E_B can be computed in two ways as shown below.

$$E_B = \frac{\text{sum of all task times}}{\text{cycle} \times \text{actual number of work centres}} = \frac{T}{C \times n} \quad \text{... (3)}$$

or

$$E_B = \frac{\text{Theoretical minimum number of work centres}}{\text{Actual number of work centres}} = \frac{n}{N} \quad \text{...(4)}$$

Note : n = Theoretical minimum number of work centres

N = Actual number of work centres

$$= \begin{cases} n \text{ if } n \text{ is integer} \\ \text{integer part of } n+1 \text{ if } n \text{ is not an integer} \end{cases}$$

4. Balance Delay

The efficiency of the selected layout is measured by the balance delay [D], which is the percentage of time that the process is idle.

$$\text{Balance Delay} = D = \frac{(NC - T)}{NC} \times 100$$

Where N = The Actual number of work centres

C = Cycle time for desired output rate

T = Sum of all task times

From the above, we can see that the layout is perfectly balanced with each work station having exactly the same amount of work, then $NC = T$ and hence the Balance Delay will be zero.

PROBLEMS ON LINE BALANCING

1. Manufacturing of an item involves 10 operations as given below.

Operation No.	1	2	3	4	5	6	7	8	9	10
Time	6	5	7	9	3	9	7	5	7	4

(i) What is the cycle time for this item?

(ii) Calculate line efficiency when the cycle time is fixed at 6 mts, 4 mts > 2 mts respectively.

Sol.:

(i) Using the given information, cycle time is computed.

$$\text{Cycle time} = \frac{\text{Total working time}}{\text{Number of workstations}} = \frac{\text{Total working time}}{\text{Number of operations}}$$

Total working time

$$= 6+5+7+9+3+9+7+5+7+4 = 62 \text{ mts}$$

$$\therefore \text{ Cycle time} = \frac{62}{10} = 62 \text{ mts.}$$

(ii) $$\text{Line efficiency} = \frac{\text{Total working time}}{\text{Total time}}$$

$$= \frac{\text{Total working time}}{\text{Cycle time} \times \text{Number of workstations}}$$

Number of workstations

$$= \frac{\text{Total working time}}{\text{Cycle time}}$$

(a) Cycle time = 6 mts

$\therefore$ Number of workstations

$$= \frac{62}{6} = 10.3 = 11$$

$$\text{Line efficiency} = \frac{62}{6 \times 11}$$

(b) Cycle time = 4 mts

Number of workstations

$$= \frac{62}{4} = 15.5 = 16$$

$$\therefore \text{Line efficiency} = \frac{62}{4 \times 16} = \frac{62}{64} \times 100 = 97\%$$

(c) Cycle time = 2 mts

$$\text{Number of workstations} = \frac{62}{2} = 31$$

$$\therefore \quad \text{Line efficiency} = \frac{62}{2 \times 31} = \frac{62}{62} \times 100 = 100\%$$

2. An assembly line consists of 7 activities with respective time requirements in each activity as shown below. The line operates 7 hours a day. An output of 600 units is desired. Calculate the following :

a) Cycle time

b) Theoretical minimum number of workers required

c) Balance efficiency

d) Balance delay

Sol.:

a) Cycle Time

$$= \frac{\text{Time is in Minutes}}{\text{Output units required in that duration}}$$

$$= \frac{\text{Available time duration}}{\text{Output units required in that duration}}$$

$$= \frac{7 \text{ hrs}}{600 \text{ units}} = \frac{7 \times 60 \text{ mts}}{600 \text{ units}} = \frac{420}{600}$$

= 0.7 mts.

b) Theoretical minimum number of work centres required '*n*'

T = Sum of all task times

= 0.62 + 0.39 + 0.27 + 0.14 + 0.56 + 0.35 + 0.28

= 2.61 mts.

Now theoretical minimum number of work centres required.

$$n = \frac{T}{C} = \frac{2.61}{0.7} = 3{,}73 \text{ workers}$$

This is theoretical value. Since you cannot have fraction, we will round off the value to the next higher number and call as the "Actual" number of work centres required 'N'. So the actual number of work centres required is 4.

n = 3.73; N = 3 + 1 = 4

c) Balancing efficiency E_n

This can be calculated using their of the two formulae given above.

$$E_n = \frac{\text{Sum of all task times}}{\text{Cycle time} \times \text{Actual number of workers}}$$

$$E_B = \frac{T}{C \times N} = \frac{2.61}{(0.7) \times 4}$$

$$\text{Percentage } E_B = \frac{2.61}{(0.7) \times 4} \times 100 = 93.21\%$$

Alternatively, E_B is given by the formula

$$E_B = \frac{\text{Theoretical minimum number of work centres}}{\text{Actual number of work centres}} = \frac{n}{N} = \frac{3.73}{4}$$

$$\text{percentage } E_B = \frac{3.73}{4} \times 100 = 93.25\% \text{(There can be some round off error)}$$

d) Balance Delay

$$D = \frac{100\,[NC - T]}{NC}$$

$$= \frac{100 \times \text{idle time}}{\text{cycle time} \times \text{actual no.of stations}} = \frac{100\,[4 \times 0.7 - 2.6]}{4 \times 0.7} = 6.75$$

The production rate of an assembly line can be varied by changing the way in which tasks are grouped together into work centres. The purpose of "Line Balancing" is to group tasks into work stations so that the desired production rate is achieved with maximum efficiency. In practice, Line Balancing may involve compromises among labour, facilities, equipment, etc.

3.

Task	a	b	c	d	e	f	g	h	i
Immediate Predecessor	-	-	a	b	c	e	d	f	h
Task Time	3	4	2	5	4	8	2	4	6

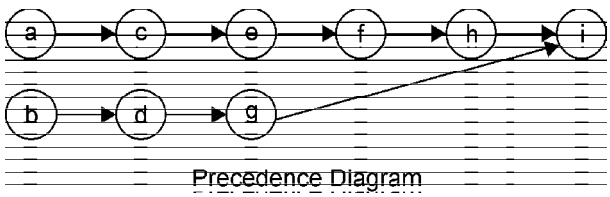
Total time per unit = 3 + 4 + 2 + 5 + 4 + 8 + 2 + 4 + 6 = 38 minutes

Cycle time = 10 minutes

Compute the efficiency of the system.

Sol.:

Step 1



Precedence Diagram

Step 2

$$\text{Min no. of workstation} = \frac{\text{Total time per unit}}{\text{Cycle time}} = \frac{38}{10} = 3.8 \cong 4 \text{ workstations}$$

Step 3

Assignment of Task :

Station 1 : a + b + c

3 + 4 + 2 = 9

Note : Total time in each station should be equal to or less than cycle time.

Station 2 : d + e 5 + 4 = 9 min

Station 3 : f + g

8 + 2 = 10 min

Station 4 : h + i

4 + 6 = 10 min.

Step 4

Idle time = Cycle time – Total time at each workstation.

Station 1 : 10 – 9 = 1 min

Station 2 : 10 – 9 = 1 min

Station 3 : 10 – 10 = 0 min

Station 4 : 10 – 10 = 0 min

Total Idle Time = **2 Min**

Step 5

$$\text{Efficiency} = \frac{\text{Total time per unit}}{\text{Cycle time} \times \text{Number of workstation}} = \frac{38}{10 \times 4} = 95\%$$

4. Design an assembly line for a cycle time of 10 min. for the following work elements.

Elements	1	2	3	4	5	6	7	8	9	10
Immediate Precedessors	-	1	1	2, 3	4	4	6	5	7, 8	9
Duration in Minutes	5	10	5	2	7	5	10	2	5	7

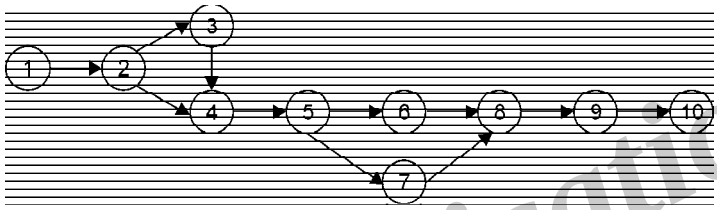
Calculation the line efficiency for the balanced line.

Sol.: **(Imp.)**

The Precedence diagram is drawn using the given information.

As the cycle is given as 10 minutes, the various elements are grouped without violating the precedence relationship and is such a way that each group is not exceeding 10 minutes. The grouped tasks from work stations are as follows :

Work Station	Elements	Duration in Minutes
A	1, 3	10
B	2	10
C	4, 5	9
D	6, 8	7
E	7	10
F	9	5
G	10	7
	Total	58



Min no. of workstation = $\frac{\text{Total time per unit}}{\text{Cycle time}} = \frac{58}{10} = 5.8 \cong 6$ Workstations.

Note : As per the table above maximum 7 workstations are required to accommodate 10 task \ maximum workstations will be considered for further computations.

Idle Time

Station A : 10 – 10 = 0 min

Station B : 10 – 10 = 0 min

Station C : 10 – 9 = 1 min

Station D : 10 – 7 = 3 min

Station E : 10 – 10 = 0 min

Station F : 10 – 5 = 5 min

Station G : 10 – 7 = 3 min

Total Idle Time = **12 Min.**

$$\text{Efficiency} = \frac{\text{Total time per unit}}{\text{Cycle time} \times \text{No.of workstations}} \% = 1 - \frac{\text{Total idle time}}{\text{Total time } (10 \times 7)}$$

$$= \frac{58}{70} = 82.85\%.$$

5. A job has been divided into four elements 1, 2, 3 and 4. The element times in minutes for the first five cycles are shown in the following table with a performance rating for each element,

(i) Compute an estimated normal time for job based on the data available.

(ii) Compute the standard time if the permissible allowance total is 25 percent of normal time.

Element	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Performance rating (%)
1.	1.51	1.63	1.45	1.55	1.72	100
2.	2.46	2.34	2.33	2.36	2.30	90
3.	1.79	3.02	1.84	1.78	1.77	95
4.	1.25	1.11	1.40	1.15	1.29	115

Sol.:

Element	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Performance rating
1.	1.51	1.63	1.48	1.55	1.72	100%
2.	2.46	2.34	2.33	2.36	2.30	90%
3.	1.79	3.02	1.84	1.78	1.77	95%
4.	1.25	1.11	1.40	1.29	1.29	115%

Average cycle time

(i) Element '1'

1.51 + 1.62 + 1.48 + 1.55 + 1.72

$$\text{Average cycle timeElement} = \frac{7.89}{5} = 1.578$$

Performance rating for element 1 = 100%

Normal time = Average cycle time × Performance ratings

N.T. = 1.578 × 100% = 1.578

$$\text{Standard time} = \frac{\text{N.T}}{1 - \text{Allowance time}}$$

$$\text{S.T} = \frac{1.578}{1 - 0.3945}$$

$$= \frac{1.578}{0.6055} = 2.606$$

Allowance time = 25% of N.T = 1.578 × 25%

A.T = 0.3945

S.T = 2.606

(ii) Element '2'

$$\text{Act} = \frac{2.46 + 2.34 + 2.33 + 2.36 + 2.30}{5}$$

$$= \frac{11.79}{5} = 2.358$$

N.T. = A.C.T $\times$ P.R

= 2.358 $\times$ 90% = 2.1222

Allowance time = 25% of 2.1222

= 0.53055

$$\text{S.T} = \frac{2.1222}{1 - 0.53055}$$

$$= \frac{2.1222}{0.46945}$$

= 4.520

(iii) Element '3'

$$\text{Act} = \frac{1.79 + 3.02 + 1.84 + 1.78 + 1.77}{5}$$

$$= \frac{10.5}{5} = 2.04$$

N.T = A.C.T $\times$ P.R

= 2.04 $\times$ 95%

= 1.938

$$\text{S.T} = \frac{\text{N.T}}{1 - \text{A.T}}$$

A.T = 25% [1.938]

= 0.4845

$$\text{S.T} = \frac{1.938}{1 - 0.4845}$$

$$= \frac{1.938}{0.5155}$$

= 3.759

(iv) Element '4'

$$\text{A.C.T} = \frac{1.25 + 1.11 + 1.40 + 1.15 + 1.29}{5}$$

$$= \frac{6.2}{5} = 1.24$$

Performance rating = 115

N.T = A.C.T $\times$ P.R

= 1.24 $\times$ 115%

= 1.426

$$\text{S.N.T} = \frac{\text{N.T}}{1 - \text{A.T}} = \frac{1.24}{1 - 0.3565}$$

A.T = N.T $\times$ 25% = 0.3565

$$= \frac{1.24}{0.6435} = 1.9269$$

2.3 FACILITY LOCATION / PLANT LOCATION

Q10. What is facility location ?

Ans : **(Aug.-21, Nov.-20)**

A plant is a place, where men, materials, money, machinery and equipment, etc., are brought together for manufacturing product. Plant location decisions are crucial because they commit organizations to long lasting financial, employment, a distribution patterns. As such, they deserve the careful attention of finance, personnel, marketing and other managers, as well as that of the operations mangers who manage the facilities.

Plant location is not a static decision that can be made and forgotten. Plant layout or facility layout choices follow the location decisions. They influence the type of equipment and level of technology employed, the flow of work and design of jobs, inventory levels, and other operating characteristics of the firm. Layout can be changed more easily than locations. However, they represent more of a continuing concern. In addition, they fall more directly within the responsibility of operations manager because they deal with the physical arrangement of productive facilities.

2.3.1 Factors Influencing Selection Plant Location

Q11. What are the factors influencing selecting of plant location ?

Ans : **(Aug.-21, Nov.-20, Imp.)**

Decision regarding location requires a careful balancing of several factors. Some of them are more important and are known as *primary factors*, while the less important one are known as *secondary factors.* Sometimes in real problem secondary factors may show greater influence in selecting the locations.

A) Primary Factors

1. **Availability of Raw Material:** In order to minimise the transport cost of raw material to the industrial plant, the nature of raw material is of great importance. A good deal of economy in transport costs can be achieved if the industries, which use weight-losing materials, are located nearer to the source of raw materials. In case industries uses ubiquitous material, the material transport cost factor do not influence the location much.

2. **Nearness of Market for the Finished Product:** Industries, using pure raw materials are generally located nearer to the market for the product produced. By locating the unit nearer to the market, the transportation cost finished goods will be minimum. In addition to this factor, the chances of finished goods getting damaged or spoiled during transport can be reduced. As the industry is nearer to the market, it can catch a big share of the market and can render quick service to the customers.

3. **Availability of Fuel and Power:** The problem of fuel and power can also be soled with reference to the nature of raw materials. Industries, which used coal as the source of power or their industries, are located nearer to the local bed. Because coal loses, substantial weight during processes. Now a day as the electricity is generally used as power source, this factor is losing its importance.

4. **Transport Facilities :** A lot of money is spent both in transporting the raw material and the finished goods. Depending on the size of raw material or finished good, a suitable method of transportation like roads, rail, water or air is selected and accordingly the plant location is decided. The point to be considered here is that the cost of transport must be kept at a minimum. This is because, the movement of material will simply add to the cost and nothing to the use/economic value of the material or product.

5. **Availability of Labour :** Another important factor influencing the location of industries is availability of suitable and adequate number of labour at a reasonable labour wages. This particu-larly true in case of plants like, tobacco companies and tea estates, etc. However, labour will not attract industry by itself as it is mobile. Any labour intensive companies have to select a location nearer to the source of labour.

6. **Availability of Water :** In case water is used for processing, as in paper and chemical industries, and is also required for drinking and sanitary purposes. Depending on the nature of plant, water should be in adequate quantity and should be of desired quality.

B) Secondary Factors

1. **Solid and Climate:** The question of soil and climate is really an influencing factor for an units processing agricultural products like tea, coffee etc. With the development in the field of heating, ventilating and air-conditioning climate of the region is not a problem these days.

2. **Industrial Atmosphere:** The industrial atmosphere cannot be measured in tangible terms, but it has a very impor-tant advantage in selecting a location for a plant. Industrial atmosphere may said to exist where people living at a place think instinctively of industry and learn the intricacies of machines without much effort. This is an added advantage for the growth of industries in a particular area.

3. **Financial and Other Aids:** The plant should be located in an area where financial institutions are available to get a part of capital as loan and getting working capital and for other financial aids.

4. **Availability of Facilities like Housing, Schools, Hospitals and Recreation Clubs:** The site should be nearer to infrastructure facilities, so that the labour will have housing facilities at a reasonable cost and they will take advantage of educational institutions to educate their children. For health problems, they can use hospitals. They can relax during off periods in recreation clubs. All the above-said facilities will help in motivating the labour to stick to the job, i.e., labour turnover will be at low rate.

5. **Momentum of an Early Start:** There are number of places where, to begin with, only one or two factories were started. With the passage of time these places gained importance and attract industries. As these number of industrial units increase, certain facilities are developed in that area. Some of the facilities are banking facility; main-tenance units and other related units will come up. With these, availability of skilled labour also increases.

6. **Special Advantages of the Place:** Sometime certain facilities are offered by the state, in case the particular region is selected. Facilities like providing subsidies, tax holidays etc. In this ways state tries to develop the under-developed areas.

7. **Personal Factors:** Sometimes, promoters, irrespective of economic factors, prefer to start their unit in their place of origin to develop the area and help the fellow community. A good example for this is Ford Company at Detroit.

8. **Historical/Actors:** Factors like personal fancies of entrepreneurs or historical incidents may in many cases lead to the development of a place as the centre of an industry. Example is development of Kanpur as textile industry centre.

9. **Political Stability:** The lack of political stability in a state makes for uncertainty in the attitude of State Governments to industries. In locating industries plan, it must be seen as to whether the State ha a record of political and economic stability.

Q12. Discuss about rural and urban location.

Ans : **(Nov.-20)**

After considering the economic factors and working out which particular site among the proposed sites, next thing is to think of whether the site should be in rural area on in urban area? In view of developing rural areas and under developed areas, now a days state is encouraging the entrepreneurs to start their units in rural and underdeveloped areas by giving certain incentives. Let us now discuss the advantages and disadvantages of rural and urban sites.

A) Selecting the Site in Urban Areas

1. Urban places generally have good transport facilities such as rail, road and airways. It will help the entrepreneurs to save time in getting the raw material from source or sending the product to the market point. Also, it provides transport to the employees.
2. Urban places are good market for products manufactured. Hence the producer can avail this opportunity to sell his goods in the local market.
3. A good mix of labour : skilled / semi-skilled / trained / experienced is available in urban areas. This is an added advantage for an entrepreneur. He can get suitable labour without any difficulty.
4. Power is easily available Corporation at a reasonable rate supply water to a certain extent.
5. Good medical facilities, good schools and colleges, banks and financial institutions are available in urban areas.
6. Sometimes for small units, which do not use heavy machines, readily built building are available for rent to start the unit without delay before getting a proper site.
7. Training facilities are available to the workers, foremen and other staff.
8. Services of professional people are available with least difficulty.
9. Many related industries, maintenance units and other facilities are available in plenty in urban areas.

Disadvantages

1. Land cost is very high and the area one can get may be vary small and limited. Hence future expansion may become a problem.
2. Cost of building construction is generally high.
3. Expansion in the same area may be a problem.
4. Local taxes and labour charges comparatively will be high.
5. Labour union problems may exist, which will strain the employee-employer relationship.

B) Selecting a Site in Rural/Sub-Urban Areas

1. Plenty of land available at reasonable price. For future expansion of the unit it will be very convenient.
2. Unskilled labours areas are available in plenty at reasonable wages. If the unit is operating on seasonal basis, then seasonal labours are also available in rural area.
3. As the labour union strength is meager, 'labour problems are less and employee and employer relations will be good.
4. Municipal and other regulations and taxes are seldom burdensome.
5. Government will give subsidies, incentive and tax holidays.

Disadvantages

1. It is difficult to get skilled labour and managers.
2. Transport facilities may not be that good compared to urban areas.
3. Availability of continuous power may be problem.
4. Good hospitals, Schools, Financial Institutions and Banks may not be available.
5. It is difficult of get ancillary service units. It is better for an entrepreneur to select a site in a place, which is not purely urban or purely rural. That is it is better to have a location in substitution area.

Q13. What is loction analysis.

Ans :

Analysis of location alternatives should consider both objective factors such a availability of proper transport facilities, availability of suitable labour, tax considerations, material cost and market potentialities and subjective factors like civic amenities. Labour union activities, weather conditions, etc. However, the analysis for the choice of appropriate location/site is based on certain methodology commonly adopted by professionals in the field. The below mentioned analysis is generally came out.

1. Cost analysis,
2. Quantities methods,
3. Weight method, and
4. Ranking method.

1. Cost Analysis

A cost study is made regarding all the alternative sites, to work out what would be the expected production cost per unit of production or what is the rate of return on investment expected and they are compared to select the optimal site. Cost analysis can be done in three ways. They are : (;) Comparative cost analysis, Rate of return analysis, (Hi) Break-even analysis.

2. Quantities Methods

The entrepreneur, who is making a choice between different sites, has to consider intangible factors in addition to the cost factors. Intangible factors, which cannot be measured quantitatively, can be expressed as significant, good, excellent, bad, etc.,

3. Weight Method

Here, a weight is allocated to each influencing factor depending on the importance of the factor. Most important factor is given a higher weight and next one is lesser weight and so on. These weight are added and the site, which gets higher total weight, is given preference. One must be grateful be careful while selecting a scale for fixing up weight.

4. Rank Method

In Ranking method, each factor is allocated a rank or a rate according to its importance. Important factor is given a rank of one and all other factors are expressed in whole numbers as multiple of the least numbers. Each rank is then multiplied by the appropriate weight factors, to get the score for each location. The scores are totaled and the site, which has higher score, is selected.

2.4 PLANT LAYOUT/FACILITY LAYOUT

Q14. What is plant layout/facility layout? Explain the objectives of plant layout.

Ans : **(Feb.-21,Aug.-19, Dec.-18, Imp.)**

Plant layout is a companion problem to facility location. The word *layout* is here used to indicate the physical arrangement of the plant and of the various parts of the plant. The layout will therefore encompass both the location of equipment within a department or shop and arrangement of departments upon a site. Which include offices, warehouses, rest rooms and other facilities associated with the total system. Thus, facility layout is the overall arrangement of machines, men materials, martial handling and service facilities and passage required to facilitate efficient operation of the production system. It integrates all aspects of production.

Determination of Layout

Whether you are preparing the layout for a new plant or want to changes the existing layout of an unit for some reason or the other the below mentioned points will generally help the operations manager. The type of layout is generally determined by :

(a) Type of product : This concerns whether the product is goods or a service, the product design and quality standards and whether the product is produced for stock or for order.

(b) Type of production process : This relates to the technology used, the type of materials handled and/or the means of providing service.

(c) Volume of production : Volume affects the present facility design and capacity utilization, plus provisions for expansion or change.

Objectives of Plant Layout

The primary goal of plant layout is to arrange all the factors of production in a most optimal way so that the production cost is kept at minimum and returns are increased and employee moral is boosted *up*. To fulfil the above goal, the plant engineer must remember certain objectives, while preparing the layout. The objectives of a good plant layout are :

1. Material handling and transport is minimized and efficiently controlled, so that the handling cost is minimized.
2. Bottlenecks and points of congestions are eliminated by using the line balancing techniques, so that raw material and semi-finished goods will move fast from one workstation to the other.
3. Workstations are designed and located suitably, so that there will be least resistance to the smooth flow of material and movement of men.
4. Sufficient space and proper location should be allocated to production centres and service centres.
5. Waiting line of semi-finished goods should be minimized.
6. Safe and proper working conditions are provided to avoid accidents & casualties.
7. Designed layout should provided with sufficient flexibility to accommodate future minute change in product design or change in the material specification.
8. Care should be taken to see that the space available is used optimally. Not only length and breadth of the building but the height of the building also to be used.
9. The layout should make the plant maintenance simple and easy.
10. Plant layout should be designed in such a way that the productivity and quality of product is increased.

11. The layout should promote the effective utilisation of manpower.

12. A good layout should maintain high turnover of work-in-process.

Q15. What are the Principles of a Good Plant Layout ?

Ans : **(Feb.-21)**

Plant layout engineer has to follow certain principles to design a good layout. There are certain principles to guide him; still the common sense is a must to get optimal result. Important principle are discussed below :

1. **Integration :** The first principle is to integrate of production centres and other facilities and means of production in a logical and balanced manner. While preparing layout we have to think of all factors of production to achieve the objectives 'of a good plant layout.

2. **Minimum Movement and Material Handling :** The movement of material and men should be minimised. Because the movement will add only to the cost of consume time unproductively. There are instances when plant managers after recognizing the defect in the layout and after careful work study changing the layout, have saved quite a good amount of money per year.

3. **Smooth and Continuous Flow of Material :** Bottlenecks, congestion points and back tracking should be removed by proper line balancing techniques so that productivity is increased.

4. **Cubic Space Utilisation :** Besides using the floor space of a shop, if the ceiling height is also utilized, more materials can be accommodated in the same shop. The vertical shape may be used to stock raw material, semi finished or finished goods or sometimes tools. When the unit is dealing with continuous production, it is better to use the vertical space for movement of material.

5. **Safe and Improved Environment :** Working places should be free from noise, dust, odors and other hazardous condition so that the workers can concentrate on their work. Work places should have safety when work is being and they are well ventilated so that the workers will work happily. This will improve the operating efficiency of workers and boost their morale. All these lead to satisfaction amongst the workers and thus better employer-employed relations.

6. **Flexibility :** In automotive and other industries, where models of product change after some time, it is better to permit all possible flexibility in layout to accommodate the change required to meet the demand of the market. The machinery is arranged in such a way that the changes of the production can be achieved at the least cost or disturbance.

2.4.1 Factors Affecting the Plant Layout

Q16. What are the factors affecting the plant layout.

Ans : **(Sep.-22)**

While preparing a layout, the layout engineer has to remember the factors, which influence the type of layout and the location of machinery or facilities in the layout. Some of the factors, which are important in nature, and discussed below :

(a) Product and Material Specification : The form of material, weight of material, physical and chemical characteristics of material used has greater influence in locating a facility. These influence all parameters of the layout. Products requiring hazardous and dangerous operations call for isolation of the facility instead of integration on a line basis.

(b) Location and Site of the Plant : The site, which has been selected, has great influence while preparing layout. A planet has to get raw material from source and send the products to the market. Hence, the receiving department and the shipping department must properly located so that the receiving and shipping will not become a problem. The attitude of the community, availability of power supply and water has influence in locating the department appropriately.

(c) Manufacturing Process : This is a very important factor to be considered while preparing a layout. The manufacturing process decides the flow of madrigal, type of machines required and the material handling facilities required. Depending on the size and weight of the machine and raw material, the working area required and additional space required to store in process inventory has to decided.

(d) Material Handling : In any manufacturing process, material handling is inevitable. Not only inevitable, but handling adds to cost nothing to value. Hence, we have to keep handling of material as low as possible, so that the production cost will be under control. This point applies to all aspects of manufacturing, i.e., raw material handling, of in-process inventory, handling of scrap and waste and finished product. Material handling and plant layout are closely related, hence the layout engineering should integrate these two, while preparing the layout.

(e) Storage of in-process inventory : While preparing layout, the material waiting time should be kept at minimum, as it adds to the cost. Hence, the layout should be designed in such a way, as far as possible material do not wait in-between two processes. If possible thought should be given to integrate movement of material while it is being processed.

(f) Plant Personnel and Employee Facilities : Facilities like rest rooms, cloak rooms vehicle parking facilities, canteen, emergency medical aids and safety guards for machines should be considered while preparing layout.

(g) Service Facilities : Service facilities related to parallel, martial, machinery and equipment, and operations should be given due considerations while preparing layout because, they play a significant role in cost reduction and in increasing productivity.

(h) Flexibility : At the time of starting, the entrepreneur might have selected best available machinery and process, but as the time passes, the method may become absolute. In such cases, the plant needs a change. Because of change in the product design or change in the material used or change in the process used, the layout may need to be changed.

(i) Work Areas and Equipment : Work areas are properly designed, so that workers can move without much difficulty and material can be handled with least difficulty. Sufficient place should be provided for maintenance personnel to attend to the repairs or maintenance of the machines.

(j) Working Condition : If this fact is given due consideration, it will maximize human data sensing, processing and transmitting abilities. The work area should have sufficient light intensity and quality without direct or indirect glare. Provision should be provided to reduce the noise due to process, control of temperature and humidity, so that the personal can work comfortability.

(k) Disposal of Waste and Dangerous Gases: Proper waste disposal facilities should be provided at appropriate phases, so that they are disposed to a remote place, so that they will not harmful to the workers or to the community living around the plant.

Q17. What are the advantages of good plant layout.

Ans :

A good layout provides many advantages to workers and to the management.

a) Advantages to Workers

1. Lesser number of martial handling and lesser operations.
2. Reduction of length of hauls and motions between operations minimised through put time and activities of workers.
3. Improved labour productivity and hence the higher wages.
4. More safety and security because of reduced accidents and severity of accidents. Better working conditions and improved efficiency.

b) Manufacturing Costs

1. Reduced Maintenance and replacement costs.
2. Minimised cost due to reduced waste and spoilage of work.
3. Improved quality of the product, reduced handling and better cost control

c) Advantages of Production Control

1. More space to production operations.
2. Better storage facility in-process inventory
3. Scope for better supervision.
4. Better utilisation of machinery and labour.

2.4.2 Types of Plant Layout

2.4.2.1 Process Layout

Q18. What is process layout ? Explain the functions of process layout?

Ans : **(Dec.-19, Dec.-18, June-18, Imp.)**

Process layout is a type of facility layout which is characterized by the presence of similar machines or similar operations at specific location. It is known by different names. Some ofthem are functional layout or layout for job lot manufacture or batch production layout.

Functioning of Process Layout

In a process layout, jobs will be processed on different machines. Process layout initiates with the supply of raw materials to a machine based on its priority. This machine can be located anywhere in the factory. After processing on $_{f}$ first machine, jobs may have to travel long distance for their further processing on subsequent machines.

At one point, the material can be taken to separate building (say for eg: heat treatment) and then brought back for further processing to the same organization. When the machines in one department are busy, then the partly finished product which are waiting for operations can be taken to store and re-issued for production depending on the demand. Such type of partly finished product will be waiting in every department. The figure given below depicts process layout.

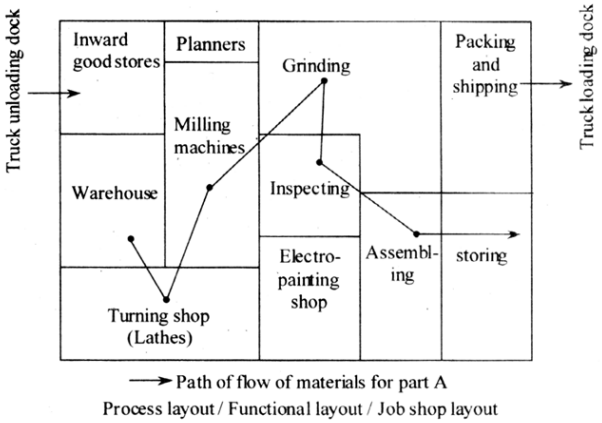


Fig. : Process Layout

In the above figure, we can see that the machines in each department will deal with the products assigned to them. These machines are known as general purpose machines. The work must be effectively assigned to each department so that no machine in any department remains idle.

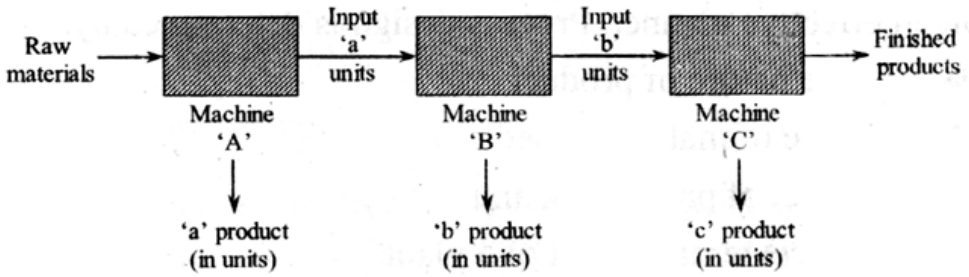
In a batch production, general purpose machines are selected so as to ensure the performance of several jobs. Based on the loading schedules, different jobs are allocated to all machines such that each job is processed at each machine (i.e., assurance needs to be provided that the machine is fully loaded optimally. Such type of layout is appropriate for intermittent type of production.

2.4.2.2 Product Layout

Q19. What is product layout ?

Ans : **(Dec.-19, Dec.-18, June-18, Imp.)**

Product layout refers to the sequential or an orderly arrangement of machines and component parts in one line based on the sequencing rules. It is also called as "straight line layout" or "layout for serialized manufacture". In this layout, there exists several machines such that the partly processed products (or WIP) of one machine becomes an input for the other machines. For example, If A, B and C are three machines arranged in a straight line such that the partly finished products of one machine say 'a' becomes an input for machine B and so on.



Q20. Distinguish between product layout and process layout.

Ans :

Product Layout	Process Layout
1. A product layout involves the arrangement of machines in a series based on the sequence of operations.	1. A process layout is a type of layout wherein the similar machines are grouped in one department.
2. Product layout is also called as straight line layout or layout for serialized manufacture.	2. Process layout is also called as functional layout.
3. The amount invested on the purchase and installation of machines in product layout is very high.	3. The amount invested on machines in process layout is very less.
4. Product layout does not provide flexibility in the production process.	4. Process layout provides greater flexibility in the production process.
5. A product layout is associated with no expansion.	5. As the capacity of various production lines can be increased easily, it is associated with greater scope of expansion.
6. In product layout, the floor area required for per unit of production is less.	6. Process layout needs more floor space.
7. As the machines are arranged sequentially, a single breakdown causes the whole system to disrupt.	7. The breakdown of equipment can be easily handled by transferring work to other machine or to other work station.
8. Product layout motivates a group of workers to increase their performance level.	8. Process layout motivates individual worker to increase his/her performance.
9. Less inspection supervision is needed during the sequence of operations.	9. Many inspections are needed during a sequence of operations.
10. In a product layout, same machine or work station will not be used for more than one operation.	10. In process layout, same machine or work-station can be used for two or more different operations.

2.4.2.3 Fixed Position Layout

Q21. Explain fixed position layout. What are the advantages and disadvantages of fixed position layout?

Ans : **(Dec.-19, Aug.-19, Dec.-18, Imp.)**

Fixed position layout deals with the transfer of productional resources such as men, machines and equipments towards the productional site which is fixed or stable. In fixed position layout, the material or primary productional requirements will be in fixed location and the tools, machinery, men and other materials will be transferred to this location. It is desirable to transfer the men and machines to the product as the cost incurred on transferring them will be less when compared to the cost incurred on transferring the bulky product. Fixed position layout is also called as static layout or fixed location layout. The figure given below depicts the fixed position layout.

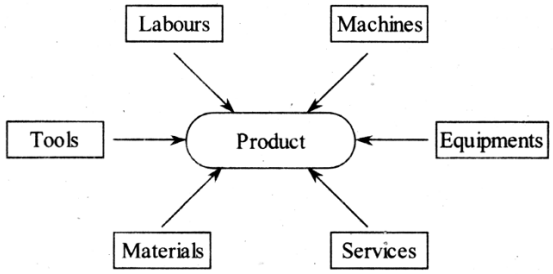


Fig. : Fixed Position Layout

Fixed position layout is widely find its applications in the manufacturing of heavy products like locomotives, ships, boilers, air crafts and generators. For example, during the construction of building, men, cement, sand, bricks, steel, wood and others are taken to the construction site which is fixed. Similarly, in hospitals also, the doctors, nurses (workers), medicines and other (materials) will be given to a patient (product) [whose position is fixed). The layout may be temporarily or permanently located.

2.4.2.4 Cellular Manufacturing Layout

Q22. Define Cellular Manufacturing Layout.

Ans : **(Dec.-19, Aug.-19, Dec.-18, Imp.)**

Cellular manufacturing layout is a type of layout where the machines are arranged in the form of cells. Each cell may function either as a product layout within a large shop or a process layout. The cells in a cellular layout are engaged in producing single parts of same machine having same features and those requiring the same production settings. The figure given below depicts a cellular manufacturing layout.

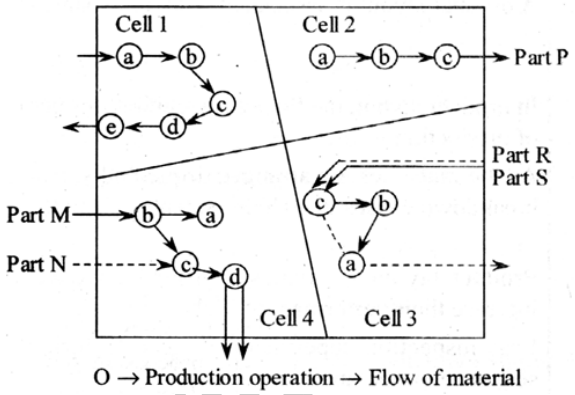


Fig. : Cellular Manufacturing Layout

In the above figure we can see that the materials can be transferred within the cells in many different forms. In the cells 1 and 2, the materials are transferred through same machines in a product focussed manner. But in cells 3 and 4, different routes are used for transferring the materials due to differences between the designs of two parts.

2.5 Service Facility Layout

Q23. Define service facility layout. Explain differnt types of service facility layout.

Ans :

Service facility layout is similar to manufacturing facility layout with few differences such as,

(a) It is more customer oriented.

(b) The seasonal demand and execution time may change in service facility layout.

(c) Customer presence creates the work flow.

Examples of service facility layouts are banks, restaurants, retailers, warehouses and offices.

Before studying the types of service facility layouts one needs to consider the following points,

1. The most important feature of services is "Diversity".
2. For each type of service, there are three dimensions i.e., standard or custom design, amount of customer contact and the combination of physical goods and intangible services.
3. Quasi-manufacturing, customer-as-participant and customer-as-product are the three types of service operations.

Types of Service Facility Layouts

The diversity of services can be observed from different service providers such as banks, retailers, hospitals, restaurants, insurance, trucking, telephones, utilities, entertainment, real estate and airlines. There exists huge diversity among these services and the layouts being used for service facilities.

One characteristic of a service business makes it different from the manufacturing operations i.e., the encounter between the customer and , the service being provided. The encounter become more extreme because when the customer meets the service provider, he/she becomes a part of production process. For example, In hospitals, the service is performed directly on the customer. The encounter could also be less extreme in a situation such as retailing where the customer can choose, pay and carryout the tangible goods. Service facility layouts are affected dramatically irrespective of the nature and intensity of this encounter.

The service facility layouts should include the following important properties,

(a) It should provide well-organized and lighted parking areas.

(b) It should include well-designed walkways to carry people to and from the parking areas.

(c) It should ensure well-marked entry ways and exits which are designed in such a manner that large number of customers are easily accommodated during peak hours.

(d) It should keep escalators and powered doors to ease the efforts of climbing stairs and opening doors.

(e) It should also provide lobbies for customers, service counters, customer waiting lines, employee workstations, cash registers, aisle ways, merchandise displays, lightning and attractive decor etc.

2.6 AGGREGATE PLANNING

Q24. Define aggregate planning. Explain the objectives, nature and input and output of aggregate plan.

Ans :

Aggregate Planning

Aggregate Planning is an immediate (annual) planning method used to determine the necessary resource capacity a firm will need in order to meet its expected demand. Aggregate planning generally includes combination of planned output, employment, sourcing, sub-contracting etc that can be planned for a period of 9-12 month. The goal of aggregate planning is to match 'demand' and 'supply' in the aggregate using mentioned combination in a cost effective manner.

Supply chains are easier to manage when demand is stationary. But when demand is seasonal, we face tradeoffs. Aggregate planning uses following 2 basic strategies or combination of both to deal with seasonal demand:

1. Level Output

It's a fixed output scheme where demand variability is met by inventory, subcontracting, overtime, cross-training etc.

2. Chase Demand

It's a make to order scheme where production rate is changed to meet demand.

Example

Suppose you are a car manufacturer. In aggregate planning, you don't differentiate a car based on model, color etc. but you decide aggregate

units of cars that can be produced. Everything like capacity, time periods, work-force etc is taken in aggregate. It gives flexibility to change plan in case of variation from expected demand.

Objectives of Aggregate Planning

The main purpose of the aggregate plan is to specify the optimal combination of production rate, workforce level, and inventory on hand. In general, the objectives of aggregate planning are :

- Minimize costs/maximize profits
- Maximize customer service
- Minimize inventory investment
- Minimize changes in production rates
- Minimize changes in workforce levels
- Minimize utilization of plant and equipment

Nature of Aggregate Planning

The aggregate plan links the strategic goals with plans for the individual products (i.e., the MPS) in a manufacturing organization. In service firm, the aggregate plan links the strategic goals with detailed workforce schedules. The primary requirements for effective aggregate planning are to determine the course the organization takes in the medium term, which the following in mind :

- Capability specifications and performance matrics
- Market inputs (demand forecasts and/or actual orders)
- Resource availability

Input and Outputs of Aggregate Plan

The following figure shows the inputs and outputs of aggregate plan.

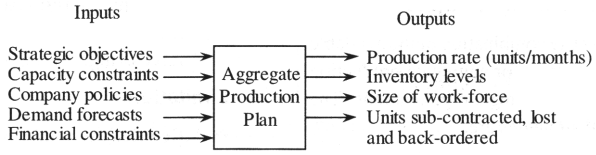


Fig.: Inputs and Outputs of an Aggregate Production Plan

2.6.1 Types / Strategies of Aggregate Plans

Q25. Explain various types of strategies used in aggregate production plans.

Ans:

Two types of plans are given below :

A) Pure Strategies

There are two puraaaaae strategies of aggregate planning which are available. They are,

(i) Level strategy

(ii) Chase strategy.

Firms may choose to utilize either one of the above two pure strategies in isolation or they may opt for a strategy that combines the two. The following reveals a detailed explanation of the above mentioned strategies.

(i) Level Strategy

This strategy is used for producing an aggregate plan that maintains a steady production rate and/or a steady employment level. Satisfaction of a firm during changes in customer demand is of prime importance. In order for this to happen, the firm must raise or lower inventory levels by estimating the increased or decreased levels of forecast demand. In circumstances of low demand, the firm uses this strategy to maintain a level workforce, and a steady rate of output. This allows the firm to establish higher inventory levels which will be absorbed during the times of increased demand. Thus, in times of increased demand, the firm is able to continue a steady production rate and/or a steady employment level. Thus, a level strategy allows a firm to maintain a constant level of output and still meet the demand. Another alternative advantage of implementing level strategy would be to meet a backlog or a back order.

(ii) Chase Strategy

This strategy maintains a coordination between demand and capacity, period by period. The ramifications might a considerable amount of hiring, firing or laying off of employees. There always exists a lack of

job security and happiness among the employees. Such firms also have to bear the burden of increased inventory carrying costs and erratic utilization of the plant is a common picture. This strategy to be implemented, requires a great deal of flexibility on the firm's part. The major advantage of implementing this strategy is that it allows the lowest possible inventory to be held by a firm and hence a considerable amount of savings. Most firm's implementing the just-in-time production concept, utilize a chase strategy approach to aggregate planning.

The other major pure strategies used in production activities in aggregate planning are,

- Varying workforce size
- Overtime
- Varying inventory
- Accepting back order
- Subcontracting.

B) Mixed Strategies

Organizations that use combination of the available alternatives to devise a strategy for aggregate production planning come under mixed strategic organizations. The three mainly used mixed strategies are,

(i) Mixed Strategy 1

In this strategy, certain number of workers are hired at the beginning of the planning horizon, constant production rate is maintained and inventory based alternatives are utilized to match the supply with demand.

(ii) Mixed Strategy 2

In this strategy, hiring or laying of workers is not allowed. The production rate is adjusted by varying the number of shifts, sub-contracting and using of inventory is made to match supply with demand.

(iii) Mixed Strategy 3

In this strategy also hiring or laying-off of workers is presented. During high demand periods, sub-contracting is used and during-low demand, inventory is used.

2.6.2 Aggregate Demand

Q26. What is aggregate demand.

Ans :

Aggregate Demand

Aggregate demand is the micro economic term that shows the relation between goods or services that are brought within a country and their prices. Goods or services purchased in the country is same as that of goods or services produced in a country. The aggregate demand comply with the law of demand which says that the people's desire to purchase goods and services increase when the prices decrease.

The aggregate demand curve is similar to the demand curve used in microeconomics. It shows the quantity demanded at each price. It describes how the quantities of goods changes, when there is a change in price. Therefore, aggregate demand curve says that gross domestic product will contract when the prices rise.

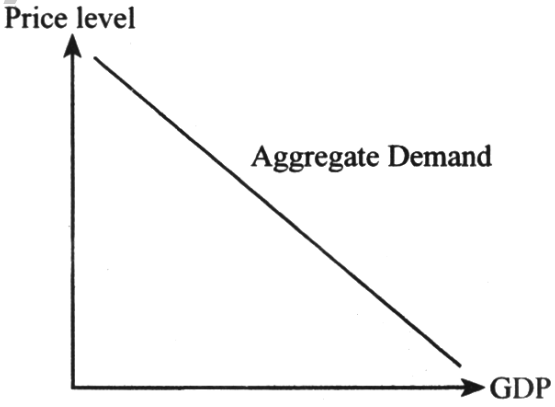
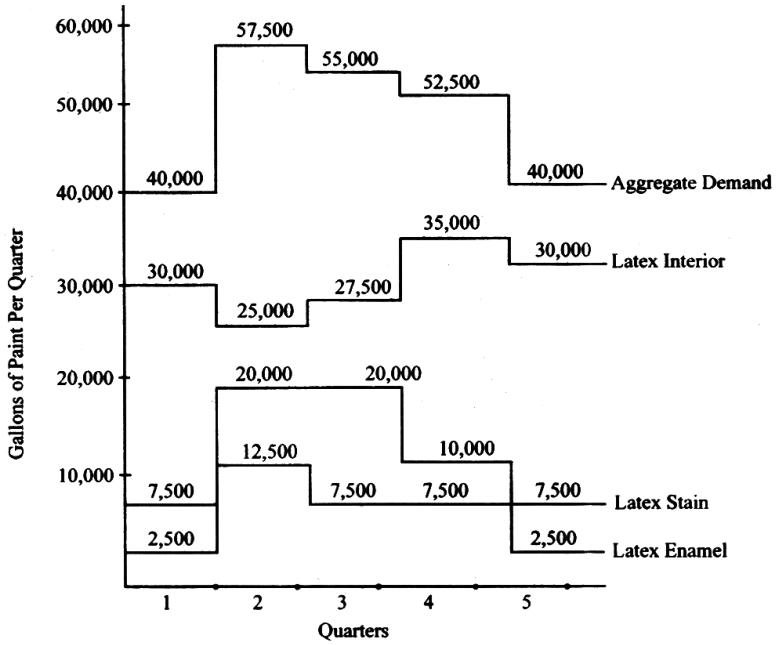


Fig.: Aggregate Demand

Demand forecasting is used for medium-range production planning and for estimating the quantity of products/services which are likely to have demand in each time period of the planning horizon.

The following example of Sherman-Brown chemical company will help you understand the concept of aggregate demand. The company develops an aggregate demand with a one-year planning horizon.



To form the aggregate demand for all products, the quarterly forecasts for three products are combined and are expressed in gallons per quarter. Similarly, the production capacities are expressed in gallons per quarter. As the aggregate plan is expressed in gallons per quarter, it is possible to scale up or down the production capacities in order to meet the demand. Aggregate planning may not be so straight forward when different products are produced.

2.6.3 Criteria for Selecting Aggregate Plans

Q27. What are the criteria for selecting aggregate plans ?

Ans :

Criteria for Selecting Aggregate Plans

The aggregate plans can be selected based on certain criteria. Firstly, different aggregate plans are compared and the most appropriate plan is selected. It we compare two capacity plans such as level capacity with inventory and matching demand, we need to determine the number of workers hired/laid off per year, and the average annual inventory level for both plans. In addition, we should also compute the annual cost of hiring and laying off workers and inventory carrying cost for each plan. If the level capacity with inventory plan is the lowest cost plan, then the operation manager would favour this plan.

Apart from the above two alternative aggregate plans, various other alternative plans can also be used such as extra days per week, shifts longer than eight hours, subcontracting, overtime, extra shifts per day etc.

Factors to be Considered in Deciding between Two Plans

The following are the important factors that are important in deciding between the two plans,

1. The costs such as cost of overtime and cost of subcontracting are the important factors.
2. Union relations is also important to maintain positive management. If the workers are willing to work the amount of overtime that would be essential, then permitting them for overtime work could be a positive factor in the future dealings.

3. If the workers spend much time on overtime on a continuous basis, then this will lead to fatigue, reduced morale and increased costs.
4. There is no guarantee that the product quality will always be better with the overtime plan as all the production would be in house and under the control of company.
5. For both the alternatives, there is a flexibility in increasing or decreasing production levels in any quarter. Nevertheless, if you select the subcontracting alternative, then the overtime will be useful in increasing the production. In contrast, if you select the overtime alternative, then it becomes easier to decrease production levels just by reducing overtime.

2.6.4 Aggregate Plans for Service

Q28. Discuss about aggregate plans for service.

Ans :

Aggregate Planning in Services

The industries such as banking, trucking, and fast foods, aggregate planning may be easier than in manufacturing. Controlling the cost of labor in service firms is critical. Successful techniques include:

1. Accurate scheduling of labor-hours to assure quick response to customer demand
2. An on-call labor resource that can be added or deleted to meet unexpected demand
3. Flexibility of individual worker skills that permits reallocation of available labor
4. Flexibility in rate of output or hours of work to meet changing demand

These options may seem demanding, but they are not unusual in service industries, in which labor is the primary aggregate planning vehicle. For instance:

- Excess capacity is used to provide study and planning time by real estate and auto salespersons.
- Police and fire departments have provisions for calling in off-duty personnel for major emergen-cies. Where the emergency is extended, police or fire personnel may work longer hours and extra shifts.
- When business is unexpectedly light, restaurants and retail stores send personnel home early.
- Supermarket stock clerks work cash registers when checkout lines become too lengthy.
- Experienced waitresses increase their pace and efficiency of service as crowds of customers arrive.

Q29. Explain the various approaches in aggregate planning of services.

Ans : **(June-18, Imp.)**

Approaches to aggregate planning differ by the type of service provided. Here we discuss five service scenarios.

1. Restaurants

In a business with a highly variable demand, such as a restaurant, aggregate scheduling is directed toward (1) smoothing the production rate and (2) finding the optimal size of the workforce. The general approach usually requires building very modest levels of inventory during slack periods and depleting inventory during peak periods, but using labor to accommodate most of the changes in demand. Because this situation is very similar to those found in manufacturing, tradi-tional aggregate planning methods may be applied to services as well. One difference that should be noted is that even modest amounts of inventory may be perishable. In addition, the relevant units of time may be much smaller than in manufacturing. For example, in fast-food restaurants, peak and slack periods may be measured in fractions of an hour and the "product" may be inventoried for as little as 10 minutes.

2. Hospitals

Hospitals face aggregate planning problems in allocating money, staff, and supplies to meet the demands of patients. Michigan's Henry Ford Hospital, for example, plans for bed capacity and personnel needs in light of

a patient-load forecast developed by moving averages. The necessary labor focus of its aggregate plan has led to the creation of a new floating staff pool serving each nursing pod.

3. National Chains of Small Service Firms

With the advent of national chains of small service businesses such as funeral homes, oil change outlets, and photocopy/printing centers, the question of aggregate planning versus independent planning at each business establishment becomes an issue. Both purchases and production capacity may be centrally planned when demand can be influenced through special promotions. This approach to aggregate scheduling is often advantageous because it reduces costs and helps manage cash flow at independent sites.

4. Miscellaneous Services

Most "miscellaneous" services—financial, transportation, and many communication and recre-ation services—provide intangible output. Aggregate planning for these services deals mainly with planning for human resource requirements and managing demand. The twofold goal is to level demand peaks and to design methods for fully utilizing labor resources during low-demand periods.

5. Airline Industry

Airlines and auto-rental firms also have unique aggregate scheduling problems. Consider an airline that has its headquarters in New York, two hub sites in cities such as Atlanta and Dallas, and 150 offices in airports throughout the country. This planning is considerably more complex than aggregate planning for a single site or even for a number of independent sites.

Aggregate planning consists of tables or schedules for (1) number of flights in and out of each hub; (2) number of flights on all routes; (3) number of passengers to be serviced on all flights; (4) number of air personnel and ground personnel required at each hub and airport; and (5) determining the seats to be allocated to various fare classes.

2.6.5 Mathematical Model for Aggregate Planning

Q30. Explain various mathematical model for aggregate planning.

Ans :

There are many aggregate output planning models that help planners formulate the aggregate output plan. The graphical, optimal, and heuristic models are some of the aggregate planning models that are discussed in the following' sections.

A) Graphical Method for Aggregate Output Planning

The graphical planning procedure is a two-dimensional model relating cumulative demand to cumulative output capacity. It is one of the techniques used in developing and evaluating various alternative plans or a combination of these alternatives. The method evaluates various alternatives plans and identifies the best plan through trial and error. The steps are as follows:

i) A graph is drawn by taking cumulative productive days for the planning time period on the X or horizontal axis, and cumulative units of output on the Y or vertical axis. The cumulative demand forecast for the entire planning time period is plotted on tine graph.

ii) Based on the aggregate planning goals, a planning strategy is selected. Proposed output for each period in the planning horizon is computed and plotted on the same axis used to plot the demand.

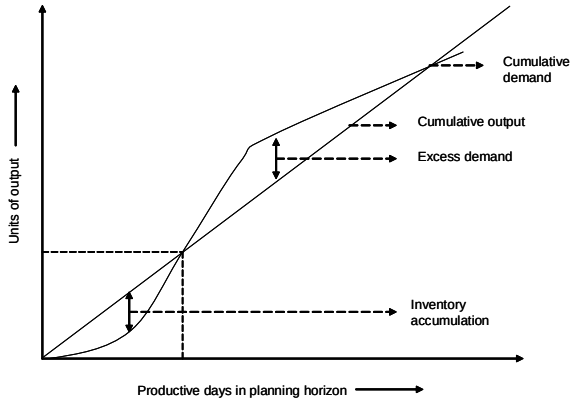
iii) The planned output is compared with expected demand and periods of excess inventory and shortages are identified.

iv) The costs involved in the implementation of the plan are calculated.

v) The plan is modified in a way to meet aggregate planning goals by repeating the steps 2 to 4 until a satisfactory plan is established.

Figure shows a graph that illustrates the above steps for level production and demand forecast. The graphical method described above is simple to understand, and requires only minimal computational effort.

q



B) Optimal Models for Aggregate Planning

1. Linear programming

The linear programming model is one of the optimal models used to formulate aggregate plans. The optimal plan for minimizing costs is identified by the linear programming procedure.

The number of units to be produced, the total number of shifts for which the plan should operate in the planning time horizon, and the amount of inventory that has to be carried in each time period, are specified by the identified plan. Linear programming is used to allocate scarce resources to strategic alternatives when the costs of various resources are linear functions of their quantities.

2. Linear Decision Rules (LDRs)

Linear Decision Rules (LDRs) are a set of equations for calculating the optimal workforce, aggregate output rate and inventory level for each time period in a planning horizon. Similar to linear programming, this method guarantees an optimal solution and eliminates trial-and-error computations. It also overcomes the limitation of linear programming by taking into account non-linear cost relationships.

This model determines the actual costs incurred due to the changes in the inventory level, production rate, and workforce size, and fits them in the form of nonlinear equations.

These equations are simplified to obtain two linear equations: for production rate, and workforce size, using calculus to minimize the total cost. These two equations can be used to determine the required workforce size and production rate (for a month) as a function of the demand forecast, the current workforce, and inventory.

One of the drawbacks of LDRs is that they must be tailored to fit each organization's specific requirements. Further, to derive proper LDRs for a particular company, extensive mathematical analysis has to be carried out. Finally, any changes in the cost relationships like increase in wages will require redoing the whole process to derive new LDRs.

3. Heuristic Models

Heuristic models are based on historical aggregate planning data available with organizations. The management coefficient model is a heuristic model which uses the regression method to identify capacity requirements based on the management's past decisions.

The management coefficient model is used to generate a set of equations that represents historical patterns of a company's aggregate planning decisions. Accumulated data on the firm's workforce, production and inventory decisions are analyzed using regression techniques.

The objective is to find the regression equations that best fit the historical data. Finally, the equations so generated are used to make future planning decisions, in a maimer similar to LDRs. Heuristic models are easy to construct if the relevant historical data is available. But heuristic models should be applied after careful consideration, as past pattern may not always be an accurate indicator of future trends.

4. Computer Search Models

Computer search methods are used when an organization lias large quantity of information on different production variables. A computer program simulates conditions under all the

possible combinations of these variables and identifies the most cost-effective combination, which satisfies the production requirements. It evaluates all possible combinations, based on specified search conditions and rules, in order to identify the optimum aggregate plan.

5. Computer Simulation in Capacity Evaluation

Computer simulation is used to evaluate the performance of a specific plan, based on real-world variables and situations. Simulation provides what-if analysis of different situations, using different variables with alternative values attached to them, to judge the performance of the system under different conditions. Complex situations can be analyzed with the help of simulation models.

2.7 MASTER PRODUCTION SCHEDULING (MPS)

Q31. What is master production scheduling.

Ans :

The Master Production Schedule (MPS) defines the type and volume of each product that is to be produced within the planning horizon. The MPS is a detailed plan that specifies the exact timing for the production of each unit. Master production schedules are also used in scheduling various stages of production, depending on the type of operations, For instance, the MPS of make-to-order organizations deals only with end- items or final products, and not components and sub-assemblies.

On the other hand, the MPS for assemble-to-order organizations concentrates on scheduling the major components that are assembled to make a product after orders are received. MPS is based on an estimation of the overall demand for the end product A final assembly schedule is developed only when customer orders are received.

2.7.1 Objectives of MPS

Q32. What are the objectives master production scheduling?

Ans :

Functions of an MPS are described below:

1. Translate aggregate plans

The master schedule is a manufacturing plan, which breaks up planned total production of the firm into groups of products or product lots. The sizes of the lots are determined in such a way that the products are economical to produce and utilize firm's facilities and resources at an optimal level.

The aggregate plan sets a level of operations that balances market demand with the material, labor and equipment capabilities of the firm, whereas the master schedule is more detailed and translates the aggregate plan into a specific number of individual products to be produced in specific time periods at specific workstations.

2. Evaluate alternative schedules

Planners use computerized production and inventory control systems with simulation capabilities to evaluate alternative master schedules. Once all the alternatives are evaluated, the detailed material and capacity requirements are identified, and the exact lead times and delivery schedules are also determined by the planners. The simulations even suggest how increased demand for one product can affect the production schedule of other products.

3. Identify material requirement

The prime input for a material requirements planning system is the master schedule. Once the master schedule is drawn up, it alerts the material requirement planning system to produce or purchase the necessary-components that are needed to meet the requirements of final assembly schedules.

4. Generate capacity requirements

Capacity requirement planning needs inputs from the material requirement plan, which in turn, is directed by the master schedule. So, the master schedule is a prerequisite for capacity planning. The master schedule reflects the most economical usage of labor and equipment capacities. If the capacity available does not satisfy the requirements of the master production schedule, either the production capacity or the MPS is revised.

5. Effectively utilize capacity

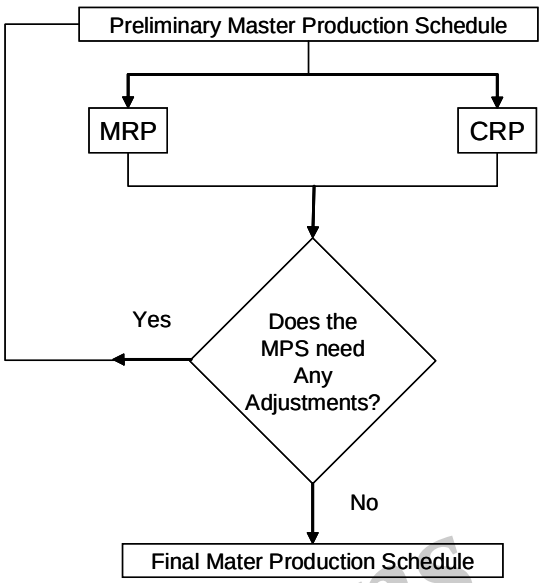
The master production schedule assigns loads for labor and equipment based on the requirements. The load report takes into account of the individual product require-ments and available resources in assigning load to individual workers, equipment and workstations. The objective is to fully utilize the available capacity.

2.7.2 Procedure of MPS

Q33. Explain the procedure of master production scheduling.

Ans : **(June-18, Imp.)**

The process of master production scheduling involves the planning of activities to determine whether or not an operation can achieve the production objectives mentioned in the MPS. Material Requirements Planning (MRP) and Capacity Requirements Planning (CRP) are the two planning activities that are a part of the master production scheduling process. CRP determines whether the existing production capacity is sufficient to achieve the objectives of the MPS. Figure. illustrates the process of master production scheduling. The following are the sequential steps involved in the master production scheduling process :



1. Determining the gross requirements of materials, components and sub - components (total demand in units of the end-product) for each product in the product line, using MRP.
2. Obtaining the net requirements for each unit of materials, components, and sub - components, after taking into considera-tion inventory on hand and inventory on order.
3. Revising the preliminary master production schedule to accommodate the inadequacy of materials in inventory, if any.
4. Converting adjusted net requirements into planned order releases (the order quantity for a specific time period) to determine unit or lot-sized production during the planning horizon.
5. Developing load reports from the planned order releases. The load report contains information on the amount of work assigned to individual workers, machines and workstations.
6. In the event of a mismatch between available capacity and required capacity, the MPS is modified or additional capacity is added.

Master production scheduling is generally based on the results of demand forecasts. These results are not always accurate and the actual

production output is not always the same as the actual market demand. To accommodate these imbalances, operations managers modify the master production schedule by

- Modifying the size or composition of the product or service temporarily.
- Allowing the inventory level to increase when the demand for the product is low and decrease when the demand is higher.
- Deferring routine maintenance and diverting labor capacity to manufacturing.
- Subcontracting the additional capacity requirements.
- Altering the prices of products to influence the demand level.

Q34. Discuss master schedule formation with an example.

Ans :

The proper implementation of the master production schedule is important for achieving the goals set in aggregate plans. As the market environment and resource availability influence the aggregate plan, they also affect the master schedule.

The two major sources of inputs that influence the MPS are forecasts and customer orders. Make-to-stock environment takes inputs from forecasts in deciding the MPS. On the other hand, make-to-order environment takes inputs from customer demand and based on that generates an MPS.

1. Make-to-stock items

The major input for the make-to-stock items in master schedule is the demand forecast. Requirements are based on the need to replenish plant or distributor inventories of end products or service parts. MPS for a make-to-stock environment is generated after taking into account the end item level. The products in a make-to- stock environment are produced in batches and the finished goods inventory for all the products are maintained constantly. Examples include FMCG firms and home appliances firms.

2. Make-to-order items

For make-to-order items, detailed scheduling of time and materials required is essential because the items and quantities specified are unique for a particular customer order. In make-to-order environment, there is no finished goods inventory. Customer orders are backlogged and production begins only after the orders have been placed. An example is jet engine production.

Example

The forecasted demand for telephone handsets for next six weeks is 30, 35, 38, 32, 32, 30. And the number of orders booked at the start of the MPS planning period is 23, 40, 24, 22, 38, and 22. Prepare an MPS schedule for the telephone set manufacturer.

Given,

Inventory on hand = 40

Lead time = 1 week

Production lot size = 80 units

Quantity on hand = 40

Sol :

1st week

Forecast for the first week is 30 units. This requirement can be satisfied by using the on hand inventory.

Projected inventory on hand at the end of first week is = On hand inventory + MPS quantity - projected requirements for the week = 40 + 0 – 30 = 10

	1	2	3	4	5	6
Forecast	30	35	38	32	32	30
Orders	23	40	24	22	38	22
Project on hand inventory	10	50	12	60	22	72
MPS quanity	0	80	0	80	0	80
MPS start	80		80		80	

2nd week

Forecast for second week is 35 units but the orders received are for 40 units. Inventory on hand at the end of first week is 10 units, which is not

sufficient to satisfy the second week's requirements. So to make up for the deficiency, organization schedules for MPS quantities. As the lead time is one week, the production should commence on first week itself to satisfy the requirements of the second week. As can be seen from the Table, MPS start quantity for first week is 80 units.

Now at the end of 2nd week projected inventory on hand = On hand inventory + MPS quantity - Projected requirements for the week

= 10 + 80 – 40

= 50 units

Similarly, projected inventory at the end each week and MPS quantities can be calculated.

From the Table, we can see there is no requirement of MPS quantities in 1st, 3rd and 5th week.

2.7.3 Time Frame of Master Production Schedule

Q35. Write a note on time frames in master production schedule.

Ans :

Time Interval and Planning Horizon for MPS

The time interval used (for example, weekly, monthly, or quarterly) depends upon the type, volume and component lead times of the products being produced.

The time horizon covered by the MPS also depends upon product characteristics and lead times. The time horizon may vary from a few weeks to an year or more and should encompass the lead times for all purchased and assembled components.

Time Fences in Master Production Schedules

MPS can be divided into four sections, each section separated by a point of time called a 'time fence'. The first section includes the first few weeks of the schedule and is referred to as 'frozen', the second section of a few weeks isreferred to as 'firm', the third section is referred to as 'full' and the last section of a few weeks is referred to as 'open'.

(i) **"Frozen"** means that this early part of the MPS cannot be changed except under extraordinary circumstances and only with authorization from the highest levels in the organization. It is not desirable to change this section of MPS because it would be costly to reverse the plans to purchase materials and produce the parts that go into the products belonging to this section of MPS.

(ii) **"Firm"** means that changes can occur in this section of MPS but only in exceptional situations

(iii) **"Full"** means that all of the available production capacity has been allocated to orders. Changes in this section of the schedule can be made and production costs will be only slightly affected but the effect on customer satisfaction is uncertain.

(iv) **"Open"** means that not all of the production capacity has been allocated and in this section of MPS, new orders are ordinarily slotted.

2.8 Sequence of Operations/ Job Sequencing

Q36. Define sequencing. What are the rules for sequencing of operation?

Ans :

Sequencing

Sequencing is the process by which different jobs waiting at their respective workstations can be processed based on their priority. Priority or importance of jobs can be determined by applying priority sequencing rules. According to the rules, the job which needs to be completed first is processed first followed by the processing of less prioritizedjobs.

When there exists V number of jobs in a queue for their processing, then an operations manager must provide an answer to a question as to which job should be processed first? This can be answered by determining the priority of all the jobs based on the priority rules.

The term "priority" denotes the processing sequence of jobs for different machines or work centres. Processing of highest priority job is done when the workcentre or the machine becomes free.

It is very difficult to select the right sequencing rule on the basis of a single criterion as there is no universally acceptable rule which can be valid under all the situations. The criteria used for selecting the right sequencing rule are as follows,

(i) Idle time

(ii) Average job lateness

(iii) Setup costs

(iv) Work in progress inventory cost

(v) Average flow time

(vi) Average number of jobs in the system

(vii) Average time to complete a job

(viii) Number or percent of late jobs.

Rules of Sequencing of Operation

The following are the rules of sequencing :

1. First Come First Served Rule (FCFS)

In FCFS rule, the jobs which arrives first at the facility or work centre will be served first. This rule is used mostly in the service centres like Banks, super markets, Insurance offices and others.

2. Shortest Process Time (SPT) Job First

In the SPT rule, the jobs having the shortest processing or operations time on the machine or at work centre will be assigned the highest priority. This rule helps in reducing the in-process inventory by giving less-priority : to the jobs that requires high processing time.

3. Longest Processing Time (LPT) Job First

In this rule, the job having the longest processing time will be processed first on the machine when compared to the other jobs waiting in a queue.

4. Least Slack (LS) Job First

According to this sequencing rule, jobs which are having least slack time can be processed first. Where slack is obtained by deducting the processing time from the total time available for performing a job.

5. Earliest Due Date (EDD) Job First

In this rule, the sequencing and processing of jobs which are waiting in the queue at the work centre are done on the basis of their due dates. Highest priority is assigned to those jobs which have earliest due data.

6. Truncated Shortest Processing Time (TSPT) Job First

In this rule, the jobs are sequenced on the basis of the SPT rule. However, SPT rule is voilated, when the jobs are waiting in a queue for a long period of time than the specified time. Such jobs are given highest priority (than any other jobs).

7. Preferred Customer Order (PCO) Rule

In this rule, highest priority is given to those jobs that are mostly preferred by the customers.

8. Random Selection

This rule is usually not used and is only used when there is no other alternative available for selection.

9. COVERT (Cost Over Time) Rule

This rule is based on the results of cost over time ratio which is the ratio of expected delay cost to the processing time. In this ratio, higher priority is given to the job having the largest value of this ratio.

10. Least Change Over Cost

In this rule, the jobs are sequenced by examining the total cost incurred on changing the machines between the jobs.

Q37. Explain various terms are used in Sequencing.

Ans :

Following are some of the terms used in performing the jobs on machines,

1. Number of Machines

Firms require various processes to complete the production of one unit of product. For example, to prepare a song, it must undergo a process of composing, singing, recording etc. Song is termed as a job whereas these processes are regarded as a number of machines.

2. Total Elapsed Time

It is the total time consumed for completing all jobs, starting from the first job to the last job and as well as idle time.

3. Processing Order

All the machines are arranged in an order to process the job for the completion of a given task.

4. No Passing Rule

Finns w'hile processing cannot change the prescribed sequence. For instance, if the firm has ordered to process the job through machine *X* first and then to machine *Y,* then it has to process in the same order.

5. Processing Time

It is the total time consumed by the jobs on each machine.

6. Idle Time on a Machine

Idle time is the time in which no processing of jobs is done on the machines during the total elapsed time. Idle time is denoted by i and it is the difference between the end of job (i – 1) and start of job i.

2.8.1 Processing 'n' Jobs with one Facility/ machine

Q38. Explain the concept of single machine I scheduling. What are the various terminologies and measures of performance in single machine scheduling?

Ans :

Single Machine Scheduling

The scheduling problem of single machine comprises 'n'jobs with the same single operation on each of the jobs. Whereas, the flow shop scheduling problem comprises V jobs with 'w' operations on each of the jobs. The job shop scheduling problem comprises V jobs with *'m'* operations on all jobs. But in job shop, the sequences of job process will be different from each other.

The important characteristics of single machine scheduling problem are,

1. It involves a set of jobs which are single operation and independent and are available for processing at time zero.
2. Irrespective of the position of job in the job sequence, the set-up time of each job is independent. Thus, the set-up time of each job can be included in its processing time.
3. It is possible to know in advance, about the jobs descriptors.
4. There is always the availability of one machine which is never kept idle when the work is waiting.
5. Every job is processed till it gets finished without any break.

Terminologies

The various terminologies used in single machine scheduling include,

1. Ready Time (R_i)

Ready time represents a time at which job T" is readily available and is taken for processing on machines. When the actual time at which the job has undergone processing is deducted from its arrival time, the resultant is said to be its ready time (R_i). According to condition-1 of the basic model, each and every job is ready for processing at zero time, i.e., $R_i = 0$.

2. Completion Time (c_i)

Completion time is the time taken by a job T to get completed in a sequence performance measures such as flow time, tardiness, lateness and so on and are used to asses schedules and job completion time (c_i).

3. Lateness (L_i)

Lateness refers to the difference between the completion time and its due date. Symbolically it is given as,

$$L_i = c - d.$$

Where,

L_i = Lateness of 'i' job.

c_i = Completion time of 'i' job.

d_i = Due date of 'i' job.

The calculation of lateness gives information pertaining to whether the jobs are succeeded in meeting its due dates or not. It may be either positive or negative. If completion time

is higher than the due date lateness is said to be positive and if the completion time is less than the due date then lateness is said to be negative.

Positive lateness indicates inability of a firm to provide good service whereas negative lateness indicates better service. Many diseconomies and costs are associated with positive lateness. However, negative lateness gives benefits to the firm. Firm usually focuses on maximizing negative lateness.

4. Processing Time (t_i)

Processing time refers to the exact time needed to process a job '/' on machines. Usually, processing time is a combination of set-up time and actual processing time.

5. Due Date (d_i)

Due date refers to the time at which the given job 'i' is required to be completed. If the job is not completed at the specified due date, then job is considered as late tardy. Due date for a job 'i' is set depending upon the customer requirements or by taking into account internal planning.

6. Flow Time (F_1)

Flow time (F) refers to the extent of time spent by the 'i' job in a system. Flow time represents the amount of time for which jobs are kept waiting in the system. This waiting time provides information related to the inventories. Flow time is calculated by subtracting ready time (R_i) from the completion time (C). Mathematically,

$$\boxed{F_i = C_i - R_i}$$

7. Tardiness (T_i)

If job completion (C.) exceeds due data, we will get positive lateness which usually constitutes, 'Tardiness'. Symbolically,

$$T_i = \text{Max}(0, C - D_i) = \text{Max}(0, L_i)$$

8. Earliness (E_i)

If the job 'j' is completed before the due date then we will get lateness as "negative". Negative lateness is referred to as Earliness (E_i). L_i, T. and E. E focuses on measuring the difference between the job completion time and the due date.

Performance Measures

The various kinds of performance measures utilized in the scheduling of a single machine includes,

1. Mean Flow Time

Mean flow time is one of the performance measures which helps in determining the average amount of time a job '/' spends in the system. 'F' is minimized in situations where fast change is needed, the aim is to reduce in-process inventory. The formula used to calculate mean flow time is as follows,

Mean flow time, $\frac{1}{n}\sum_{i=1}^{n} F_j$

The formula for maximum flow time is,

Maximum flow time, $F_{mav} = \underset{1\le i\le n}{\text{Max}}\{F_j\}$

2. Mean Tardiness

Mean tardiness becomes a performance measure when penalty per unit of time is incorporated in the objective function of the company and if jobs are completed beyond their specified due dates.

The formula to calculate Mean Tardiness is given by,

Mean tardiness, $T = \frac{1}{n}\sum_{i=1}^{n} T_j$.

3. Maximum Tardiness

In order to calculate the maximum tardiness, individual tardiness for each job needs to be calculated. The tardiness calculated for all the jobs is compared to identify the job which has maximum value. The job with maximum tardiness is denoted by ^tT '.

Formula,

Maximum tardiness (F_{max}) = $\underset{1\le i\le n}{\text{Max}}\{T_1\}$.

4. Number of Tardy Jobs

'Number of tardy jobs' represent the total number of jobs that need to be completed.

Formula,

Number of tardy jobs, $N_T = \sum_{i=1}^{n} f(T_j)$

PROBLEMS

6. XYZ expressions, a house painting contractor has five houses to paint. Following are the estimated times required to paint each house and due date for completion.

House	Estimated time (days)	Due date
A	2.5	8
B	4.0	10
C	3.0	7
D	5.0	14
E	2.0	16

Use the shortest processing time rule to sequence the five jobs. Compute average flow time and average tardiness per job using this sequence.

Use earliest due date rule to sequence the five jobs, compute average flow time and average tardiness per job using this sequence.

Sol :

(a) Shortest Processing Time Rule

According to SPT rule the jobs are to be arranged in an increasing order of the processing times.

Job Order	Processing Time(PT)	Cumulative PT(CPT)	Due Date	Tardiness
E	2.0	2.0	16	0
A	2.5	4.5	8	0
C	3.0	7.5	7	0.5
B	4.0	11.5	10	1.5
D	5.0	16.5	14	2.5
Total		42.0		4.5

(i) Average flow time

$$= \frac{\Sigma CPT}{\text{Number of jobs}} = \frac{42}{5}$$

= 8.4 days

(ii) Average tardiness/job,

$$= \frac{\text{Total tardiness}}{\text{Number of jobs}} = \frac{4.5}{5} = 0.9$$

(b) Earliest Due Date Rule (EDD)

According to this rule jobs needs to be arranged in increasing order of due dates.

Job Order	Due Date	Processing Time	Cumulative PT	Tardiness
C	7	3.0	3.0	0
A	8	2.5	5.5	0
B	10	4.0	9.5	0
D	14	5.0	14.5	0.5
E	16	2.0	16.5	0.5
Total			49	1.00

(i) Average flow time $= \frac{\Sigma CPT}{\text{Number of jobs}} = \frac{49}{5} = 9.8$ days

(ii) Average tardiness/job $= \frac{\text{Total tardiness}}{\text{Number of jobs}} = \frac{1.00}{5} = 0.2$

7. The following data are related to a single machine scheduling problem:

Job	1	2	3	4	5
Processing time (min)	15	4	5	14	8

Find the optimal sequence which will minimize the mean flow time and also obtain the minimum mean flow time.

Sol :

The jobs are arranged as per the Shortest Processing Time [SPT].

Jobs	Processing Time
J_2	4
J_3	5
J_5	8
J_4	14
J_1	15

The job sequence which will minimize the mean flow time is [2 – 3 – 5 – 4 – 1].

Computations of Flow Time

Job	Processing Time	Cumulative PT
2	4	4
3	5	9
5	8	17
4	14	31
1	15	46

$$\bar{F} = \frac{1}{5}\sum_{j=1}^{5} F_j = \frac{1}{5}\,[4 + 9 + 17 + 31 + 46]$$

$$= \frac{1}{5}\,[107]$$

$$= 21.4 \text{ hours}$$

$\therefore$ The minimum mean flow time = 21.4 hours.

2.8.2 Processing 'n' jobs with two facilities/machine

Q39. How is sequencing done for n-jobs on two machines

Ans :

Johnson's rule is a technique for minimizing make span for a group of jobs to the processed on two machines or at two work centres.

Conditions

a) Job time (including setup and processing) must be known and constant for each job at each work-centre.

b) Only two machines A and B are involved and all jobs must follow the same two-step work sequence i.e., AB.

c) All units in a job must be completed on machine A before the job moves to machines B.

d) Expected processing time on machine A is A_1, A_2, A_3.....A_n. On machine B is B_1, B_2, B_3.... B_n, of jobs "1, 2, 3, ... n".

Steps of Johnson's Rule :

1. Select the job with the shortest processing time

	Processing time (Jobs)
Machine A	A_1, A_2, A_3 ..... A_n
Mach B	B_1, B_2, B_3 ..... B_n

2. i) If the shortest processing time is A_r on machine A place the r^{th} job in the beginning of the sequence and do not consider it again.

   ii) If there is a tie among A_r q, look for the corresponding times in machine B. The job with largest time in B_q among ties is placed first in the sequence and the next job is placed after this in the sequence.

   iii) If here is a tie among B_q S, look for the corresponding times in machine A. The job with largest time in A_q among ties is placed last in the sequence and the next job is placed before this in the sequence.

3. The remaining (n – 1) jobs are sequenced by repeating steps 1 and 2 by deleting the processing times of the assigned jobs on both the machines.

4. The process is continued by placing the jobs next to first or next to last and so on till the optimum sequences obtained.

5. The total elapsed time and idle times for the optimum sequence are computed using the following formulae.

   a) Total Elapsed Time : Time between starting the first job in the optimum sequence on machine A and completing the last job in the optimum sequence on machine B.

   b) Idle Time on Machine A : (Time when the least job on the optimum sequence is completed on machine B).

   (Time when the last job on the optimum sequence is completed on machine A)

PROBLEMS

(I) 'N' JOBS ON 2 MACHINES

8. Five jobs are to be processed on two machine. Determine a sequence that will minimize the total completion time for this group of jobs. Processing times are as follows :

Jobs/Machines	J_1	J_2	J_3	J_4	J_5
M_1	10	5	15	22	3
M_2	6	8	12	4	15

Sol.:

Jobs/Machines	J_1	J_2	J_3	J_4	J_5
M_1	10	5	15	22	3
M_2	6	8	12	4	15

Step 1 : Select the job with the shortest processing time. It is job J_5 on M_1 i.e., 3.

Step 2 : Since the shortest time is on machine 1, place the job J_5 in the first of the sequence eliminate job J_5 from further consideration.

Sequence	J_5				

Step 3 : Consider the remaining data

	J_1	J_2	J_3	J_4
M_1	10	5	15	22
M_2	6	8	12	4

Step 4 : Repeat step 1 – 3 for the remaining jobs. Shortest time is 3 of Job J_4 on M_2. Schedule it last and eliminate J_4.

Sequence	J_5				J_4

	J_1	J_2	J_3
M_1	10	5	15
M_2	6	8	12

The minimum among the remaining is

Time 5 for job J_2 on machine M_1.

Since the shortest time is one first machine, place this job J_2 in the beginning of the sequence after J_5.

Sequence	J_5	J_2			J_4

The job J_2 is eliminated from processing time table

	J_1	J_3
M_1	10	15
M_2	6	12

The shortest time is = 6 for Job (J_1) on machine 2.

Place this Job (J_1) last in the sequence before J_4.

Sequence	J_5	J_2		J_1	J_4

The only job remaining to be assigned is J_3 and place this in the gap in the sequence to get the optimum sequence.

Optimum Sequence	J_5	J_2	J_3	J_1	J_4

Step 5 : Computation of times

Jobs	Machine M_1				Machine M_2			
(As per optimum) Sequence	In time (Start)	Process Time	Out time (End)	Idle time	In time (Start)	Process Time	Out time (End)	Idle time Time
J_5	0	3	3	0	3	15	18	3
J_2	3	5	8	0	18	8	26	0
J_3	8	15	23	0	26	12	38	0
J_1	23	10	33	0	38	6	44	0
J_4	33	22	55	4	55	4	59	11
			Total	4			Total	14

Calculation to determine the throughout time and idle times.

For machine 1

Start time of job = End time of preceding job.

Idle time = Zero for all jobs except last job.

Last job idle time = end time of last job in machine 2 –end time of last job in machine 1

i.e., 59 – 55 = 4

For Machine 2

Start time = End time of preceding job on M_2

OR

= End time of corresponding job on M_1.

(Whichever is Max)

Total elapsed time = 14

To determine Idle Time of machine for each job.

Idle time = In time of that particular job – out time at predecessor job.

E.g. Idle time of J_2 = In time of J_2 – out time of J_1

On respective machine

Total idle time = 4 + 14 = 18

Optimal Sequence : $J_5 – J_2 – J_3 – J_1 – J_4$.

9. A group of six jobs is to be processed through a two machine flow shop. The first operation involves cleaning and the second involves painting. Determine a sequence that will minimize the total completion time for this group of jobs. Also compute the time.

Job	A	B	C	D	E	F
Cleaning (M_1)	5	4	8	2	6	12
Cleaning (M_2)	5	3	9	7	8	15

Sol :

Johnson's Rule

Step 1: Select the job with the shortest processing time. It is job D, with a time of 2 hours on M_1.

1st	2nd	3rd	4th	5th	6th
D					

Step 2: Do not consider job D, Job B is the next shortest time schedule it last and eliminate job B from further consideration.

D					B

Step 3: The remaining jobs are their times are

Job	A	C	D	E
M_1	5	8	6	12
M_2	5	9	8	15

Note that there is a tie for the shortest remaining time : Job A has the same time at each work i.e., cleaning and painting.

It makes no difference, then, whether we place it towards the beginning or the end of the sequence. Suppose it is placed towards the end. We now have

D				A	B

Step 4: Repeat step 1 – 3

D	E			A	B

The shortest remaining time is six hours for E.

Optimal sequences is

D	E	C	F	A	B

Step 5: Computation of time

Jobs	M_1 (Cleaning)				M_2 (Printing)			
	In	Process	Out	Idle	In	Process	Out	Idle
D	0	2	2	0	2	7	9	2
E	2	6	8	0	9	8	17	0
C	8	8	16	0	17	9	26	0
F	16	12	28	0	28	15	43	2
A	28	5	33	0	43	5	48	0
B	33	4	37	14	48	3	51	0
			Total	**14**			**Total**	**4**

Idle Time : For M_1

Start time of job = End time of preceding job

Idle time = Zero for all jobs except last job

Last job idle time on M_1 = End time of last job in M_2 – End time of last job in M_1

= 15 – 37 = 14 hrs.

For M_2

Start time = End time of preceding job on M_2

OR

= End time of corresponding job or M_1

(Whichever is maximum)

Idle Time

i) In the beginning 2 hours

ii) Difference between, job C on M_2 and job F on M_1

i.e., M_2 was idle for (28 – 26) 2 hrs.

Total idle time of M_2 is = 1 + i = 2 + 2 = 4 hrs

Total idle time = 14 + 4 = 18

2.8.3 Processing 'n' Jobs with three facilities/machines

Q40. State the procedure for Processing 'n' Jobs with three facilities/machines

Ans :

If the problems are of N jobs on three machines, first it must be converted into TV jobs on two machines. Inorder to convert, the following procedure is followed,

Optimal solution for sequencing problems involving *'1C* jobs on three machines can be obtained by extending the Johnson's rule. To adopt this method, either or both of the following conditions should be satisfied. If not adopt CDs method.

Step 1

Consider three machines A, B and C on which '1C jobs have to be performed in the order ABC.

Condition 1

The minimum of the times for different jobs on machine A is at least equal to the maximum of the times of different jobs on machine B.

i.e., $\boxed{\min A_i \geq \max B_i}$

Condition 2

The minimum of the times for different jobs on machine C is at least equal to the maximum of the times of different jobs on machine B.

i.e., $\boxed{\min C_i \geq \max B_i}$

Step 2

Replace the given problem with the equivalent problem involving '1C jobs and two fictitious (imaginary) machines G and H with processing times as follows,

$G_i = A_i + B$. (i.e., i = 1, 2,..., n) and

$H_i = B_i + C$ (i.e., i = l, 2, ... , n)

Step 3

For problem obtained in step 2, apply the method of Johnson's rule adopted for sequencing '1C jobs through two machines.

Step 4

Identify the smallest processing times among G.'s and H's.

Step 5

If the smallest time is on machine G, place the job in the beginning of the sequence. If the smallest time is on machine H, place the job to the last in the sequence.

Step 6

Delete the assigned job from processing time, repeat steps 4 and 5 for the remaining jobs till all the jobs are assigned.

Step 7

The sequence so obtained is optimal sequence for the original problem and compute total elapsed time and idle time using this sequence for each machine.

PROBLEM

10. In a both production five jobs A, B, C, D and E are required to be processed on three machines as detailed below. What is the optimum sequence and elapsed time ?

Process, Time on Machine	Jobs				
	A	B	C	D	E
Cleaning	7	6	8	9	10
Machinery	1	4	5	2	3
Painting	3	2	4	5	7

Sol :

Johnson's Rule

Step 1: Check of either of both the following conditions are satisfied.

Condition 1: Min Cleaning $\geq$ Max Matching

$6 \geq 5$ (Condition satisfied)

Condition 2: Min (Painting) $\geq$ Max (Machining)

$2 \geq 5$ (Condition satisfied)

Step 2: Creates a 2 fictitious machines H_i & G_i

H_i = Cleaning + Machining

G_i = Machining + Planning

Jobs	H_i	G_i
A	8	4
B	10	6
C	13	9
D	11	7
E	13	10

Step 3 : Apply Johnson's rule

Optimal Sequence	E	C	D	B	A

Computation of Times

Job	Machine (Cleaning)				Machine (Matching)				Machine (Painting)			
	In	Process	Out	Idle	In	Process	Out	Idle	In	Process	Out	Idle
E	0	10	10	0	10	3	13	10	13	7	20	13
C	10	8	18	0	18	5	23	5	23	4	27	3
D	18	9	27	0	27	2	29	4	29	5	34	2
B	27	6	33	0	33	4	37	4	37	2	39	3
A	33	7	40	0 + 4	40	1	41	3 + 3	41	3	44	2
Total				4				29				23

Idle Time For

Cleaning = 4 min i.e., 0 + (44 – 40)

Matching = 29 min i.e., 26 + (44 – 41)

Painting = 23 min

Total elapsed time = 56 Minutes.

11. A factory received 6 jobs orders, which required processing on three machines M_1, M_2 and M_3. The factory operates for 40 hours a week. The time required by each job on the three machines is given below. On the basis of the given information determine whether the company needs to work overtime to finish all the tasks in a week's time.

Job	J_1	J_2	J_3	J_4	J_5	J_6
M_1	4	5	6	2	4	7
M_2	3	4	2	1	4	5
M_3	6	7	5	6	8	9

Sol.:

Here 6 jobs have to be scheduled on three machines. In order to use Johnson's rule for solving the problem, any of the following conditions must be met.

Min $M_1 \geq$ Max M_2 (or) Min $M_3 \geq$ Max M_2

Now let us consider to virtual machines (Dummy) H_i and G_i for which the processing time can be calculated as

$H_i = M_1 + M_2$

$G_i = M_2 + M_3$

Jobs	$H_i = M_1 + M_2$	$G_i = M_2 + M_3$
J_1	7	9
J_2	9	11
J_3	8	7
J_4	3	7
J_5	8	12
J_6	12	14

Using Johnson's Rule, we get the optimal sequence as

J_4	J_1	J_5	J_2	J_6	J_3

Now based on this sequence we would calculate the total elapsed time.

Computation of Time

Job	M_1				M_2				M_3			
	In	Process	Out	Idle	In	Process	Out	Idle	In	Process	Out	Idle
J_4	0	2	0	0	2	1	3	2	3	6	9	3
J_1	2	4	6	0	6	3	9	3	9	6	15	0
J_5	6	4	10	0	10	4	14	1	15	8	23	0
J_2	10	5	15	0	15	4	19	1	23	7	30	0
J_6	15	7	22	0	22	5	27	3	30	9	39	0
J_3	22	6	28	16	28	2	30	1 + 14	39	5	44	0
Total				**16**				**25**				**3**

Total elapsed time

= Idle time of M_1 + Idle time of M_2 + Idle time of M_3

= 16 + 25 + 3 = 44 hrs.

12. Find the sequence that minimizes total machining time to complete the following data.

Job	A	B	C	D	E	F
M I	4	9	8	5	10	9
M II	5	4	3	6	2	5
M III	7	8	6	12	6	7

Sol.:

Johnson's Rule (Extension)

Step 1 : Check the condition

Condition 1

Min M I $\geq$ Max M II

$4 \not\geq 6$

Condition not satisfied.

Condition 2

Min M III $\geq$ Max M II

6 = 6

Condition satisfied

Condition 2 has been satisfied. So proceed to step 2.

Step 2 : Create two dummy machine H_1, and G_1

H_i = I + II; G_i = II + III

Jobs	H_i	G_i
A	9	12
B	13	12
C	11	9
D	11	18
E	12	8
F	14	12

Step 3 : Apply Johnson's rule to the above table to get the optimal sequence.

Sequence I						E
Sequence II	A				C	E
Sequence III	A	D			C	E
Optimal Seq	A	D	B	F	C	E

Computation of Time

Job	M_1				M_2				M_3			
	In	Process	Out	Idle	In	Process	Out	Idle	In	Process	Out	Idle
A	0	4	4	0	4	5	9	4	9	7	16	9
D	4	5	9	0	9	6	15	0	16	12	28	0
B	9	9	18	0	18	4	22	3	28	8	36	0
F	18	9	27	0	27	5	32	5	36	7	43	0
C	27	8	35	0	35	3	38	3	43	6	49	0
E	35	10	45	0 + 10	45	2	47	7 + 8	49	6	55	0
Total				**0 + 10**				**22 + 8**				**9**

Idle Time on :

Machine I = 10

Machine II = 30

Machine III = 9

Total Idle time = 10 + 30 + 9 = 49 Hours.

Q41. Explain CDS method of sequencing with the help of an illustration. Explain the processing of 'n'jobs through 'm' machines.

Ans :

Jobs are to be processed in II, I, III order. Therefore, first change the order of machines to II, I, III.

Jobs machines	J_1	J_2	J_3	J_4	J_5	J_6
M/C II	10^{-}	18	8	22	14	8
M/CI	18	16	14	20	16	10
M/C III	20	12	6	18	18	6

Condition 1

min M/C-II $\geq$ max m/c-I

= 8 $\not\geq$ 20

Condition 2

min M/C-III > max M/C-I

= 6 $\not\geq$ 20

Since, both conditions are not satisfied, CDs method is adopted.

Number of stages = Number of machines -1 = 3 -1 = 2

Stage I $\rightarrow$ Consider first and last machines.

Stage II $\rightarrow$ Consider first two and last two methods.

Stage I

Consider II and III machines (order : II, 1, III)

Machines/Jobs	J_1	J_2	J_3	J_4	J_5	J_6
M/C II	10	18	8	22	14	8
M/CIII	20	12	6	18	18	6

Therefore optimal sequence is,

J_1	J_5	J_4	J_2	J_3	J_6

Stage II

Consider M(II + I) and M(I + III)

Machines/Jobs	J_1	J_2	J_3	J_4	J_5	J_6
M/C II + I	28	34	22	42	30	18
M/C I + III	38	28	20	38	34	16

Therefore, optimal sequence is,

J_1	J_5	J_4	J_2	J_3	J_6

The sequence (out of the two stages) which gives the minimum total elapsed time is to be chosen. As the sequenc is same in both the stages, the optimum sequence is same as in both stages.

Jobs	Machine II				Machine I				Machine III			
	In time	Process time	Out time	Idle time	In time	Process Time	Out time	Idle time	In time	Process time	Out Time	Idle Time
J_1	0	10	10	0	10	18	28	10	28	20	48	28
J_5	10	14	24	0	28	16	44	0	48	18	66	0
J_4	24	22	46	0	46	20	66	2	66	18	84	0
J_2	46	18	64	0	66	16	82	0	84	12	96	0
J_3	64	8	72	0	82	14	96	0	96	6	102	0
J_6	72	8	80	0+32	96	10	106	0+6	106	6	112	4
Total				32				18				32

Total elapsed time = 112.

Idle time for machine II = 32.

Idle time for machine I = 18.

Idle time for machine III = 32.

2.9 MAINTENANCE MANAGEMENT

Q42. Define maintenance management. State the objectives of maintenance management.

Ans : **(Nov.-20, Imp.)**

Maintenance management deals with directing and organising the resources in an orderly manner for administering the availability and performance of industrial units to a certain level. It supports production function and maintains the machinery, equipment and plant services in a good operating condition. The activities involved in maintenance management includes: Maintenance planning. Maintenance scheduling, Repairing, breakdown and preventive maintenance and control maintenance costs.

Objectives of Maintenance Management

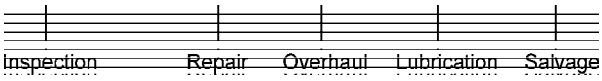
Maintenance management has the following objectives,

1. To reduce the loss of productive time due to equipment failure
2. To reduce the repair time and repair cost
3. To optimally utilise maintenance personnel and equipments
4. To enhance the quality of products and to bring improvement of productivity.
5. To reduce the losses incurred due to stoppage of production
6. To reduce the frequency of accidents by regularly carrying out the inspection and repair of the safety devices.
7. To maintain all productive assets in a good operating condition
8. To extend the life of capital assets by i mproving their handling mechanisms.
9. To reduce the total maintenance cost which is a collection of cost of repair, cost of preventive, maintenance and inventory carrying costs.

Q43. Explain the Functions of Maintenance Management.

Ans :

The basic function of any maintenance activity is to maintain the facility and its equipment in a condition to meet normal operating requirement. The basic function can be performed by the following.



1. Inspection

Maintenance inspection involves periodic inspection of machines and equipment of ensure safe and efficient operation, making certain that equipment requiring work at specified periods receives - proper attention, determination of repair feasibility and control of the quality of work accomplished by maintenance group. Inspection implies detection of faults before they develop into breakdown of the equipment. It is an expensive strategy and has to be used selectively. It is superfluous to perform inspection upon machines that are not critical.

2. Repair

When any item or its component breakdowns, then the process of repairing the component or replicating the item or part of it by another item to restore the item in working order is known as Repair.

3. Overhaul

This is another routine and regular maintenance function falling under preventive maintenance. The frequency of overhauling is far less then lubrication and inspection. Here the machine is stripped and the various parts are cleaned and oiled and critical components replaced.

4. Lubrication

Proper lubrication is the essence of any good maintenance system. The cause of most of the breakdown will be traced to failure of the lubrication plan. Lubrication converts solid friction into fluid friction, thereby, reducing

the gradual damage to the moving parts considerably. It prolongs the life of the equipment.

Proper lubrication means the use of right lubricant, at the right time, in right quantity and proper care of lubricants to prevent their contamination. Cleanliness of the surroundings and the containers is of utmost importance as the contaminated oil instead of reducing friction would cause wear.

5. Salvage

Any item/equipment is classified as Salvage when it cannot be repaired or can not be brought to desired level of performance. In that case the item is to be replaced by new one to bring back the system into operation.

Q44. What are the advantages and disadvantages of maintenance management?

Ans :

Advantages of Maintenance Management

i) Better performance with corresponding decrease in costs.

ii) Maintenance jobs are quite unpredictable in occurrence and in time. Reduction in maintenance delays can be done through planning and scheduling.

iii) Reduction in downtime of equipment/ machines.

iv) Improvement in quality of the work.

v) Better supervision.

vi) Identification of training needs.

vii) Helps in introduction of incentive schemes.

Limitations of Maintenance Management

Every work performed in maintenance department is of different type. Therefore the maintenance work cannot be standardized. The type of techniques to be used to establish a standard would depend on the size and type of industry and the complexity of the job.

2.9.1 Repair Programmes

Q45. Define repair programmes. Explain the relationship between cost of interruptions to production and cost of making repairs.

Ans :

Repair Programmes

The repair programmes are executed by operations manager to attain the following objectives,

(i) To avoid interruptions to production, the equipment is repaired. This objective has direct impact on production costs, production capacity, product quality and customer satisfaction.

(ii) To manage the repair crew costs including overtime labour and straight-time costs.

(iii) To manage the operation costs of repair shop.

(iv) To control the investment in replacement of spareparts which are used at the time of repairing machines.

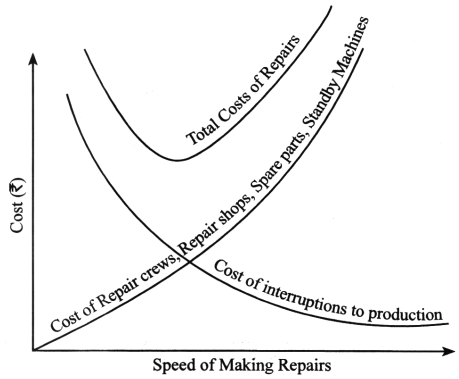
(v) To control investment in replacement spare machines or standby machines or backup machines.

(vi) To carryout the required repairs at each malfunction.

Relationship between the Costs of Interruptions to Production and the Costs of Making Repairs

To repair production equipment and buildings, repair specialists, production workers, spare parts and supplies, specialized tools and machines, repair shops and standby machines are used. Repairs are carried out in case of emergency to avoid interruptions to production, to rectify unsafe working conditions and to enhance product-quality. However, the production workers and repair specialists may require to work overtime and are shifted from less important projects. To make appropriate decisions during repairing of equipments, the maintenance supervisors and engineers collaborates with the workers. Malfunctioning machines are removed and standby machines are placed. The main aim in repairs is to

reduce the interruption to production. To attain this objective, quick response times and fast repair jobs are necessary. The following figure represents how the managers should settle down the cost of making repairs against the cost of interruptions to production.



The large repair crews, the use of overtime in repairs, managing large capacity repair shops and standby machines are combinely used for decreasing the costs of interruptions to production and to speed up the repairs. Nevertheless, at a certain point, it is not possible to balance the cost of speedy repairs by savings in interruptions to production. Managing the repair programmes involves a major issue i.e., to balance the cost of repair crews, spare parts, repair shops and standby machines against the requirement for speedy repairs.

Q46. Write a note on,

(a) Breakdown trigger repairs and corrective actions.

(b) Early parts replacement policies.

Ans :

(a) Breakdown Trigger Repairs and Corrective Actions

Two actions are triggered after the equipment crash. They are,

1. A quick repair is made to the malfunction machinery as to get the equipment back into production process.
2. For eradicating the reason of crash and the necessity for the repairs in the future, a program is developed. The program involves modification and redesign of the malfunctioned machine and the product under process. It also includes providing training to the workers of production to ensure improvement in machine care, lubrication, frequent adjustments and preventive maintenance inspections.

(b) Early Parts Replacement Policies

The maintenance supervisors should examine how huge the repairs are and when there is a need of repair in production machines. The extent of repairs could be in the following range,

1. For the equipment to work in progress, small repairs are enough.
2. Repair has to be made for the malfunctioned equipment and the worn out parts should be replaced.
3. A major repair of the equipment is performed.
4. An old equipment is to be replaced with new equipment.

Based on the type of machine, the operations manager should develop the policies for performing the repairs. Example

Assume that a specific equipment is crashed. The following are the policies that are followed by the workers who are going to perform repairs on the crashed equipment.

(a) Only the crashed parts of the equipment should be repaired or replaced.

(b) Crashed parts of the equipment are repaired or replaced and all Type *A* parts with more than 1000 hours of service are also repaired or replaced.

(c) Crashed parts of the equipment are repaired (or) replaced and all Type *A* parts with 1000 hours and Type *B* parts with 1500 hours of service are also repaired or replaced.

The operations managers can use computer simulation when they have the information regarding the frequency of crashes in equipment parts, cost of repairs (or) crashed and cost of early replacement of parts before crashing and other early replacement policies.

Q47. What are the different types of maintenance management system ?

Ans : **(Sep.-22, Imp.)**

Types of Maintenance

Equipment requires periodic maintenance. Belts need adjustment, alignment needs to be maintained, and proper lubrication on rotating equipment is required. In some cases, certain components need replacement. The following are the different types of maintenance are given below:

1. Break down maintenance

Under this type of method, a machine allows to operate till it breaks. No actions or efforts are taken to maintain the equipment as the designer originally intended to ensure design life is reached. In the case of new equipment, we can expect minimal incidents of failure.

2. Preventive maintenance

This type of maintenance is preventive in nature. Preventive maintenance is for increasing the reliability of the equipment. By simply expending the necessary resources to conduct maintenance activities intended by the equipment designer, equipment life is extended and its reliability is increased.

3. Predictive maintenance

Predictive maintenance differs from preventive maintenance. Preventive maintenance is time-based. Predictive maintenance can be defined as Measurements that detect the onset of a degradation mechanism, thereby allowing causal stressors to be eliminated or controlled prior to any significant deterioration in the component physical state. Results indicate current and future functional capability.

4. Routine Maintenance

Routine maintenance involves inspection, cleaning, lubrication and repair of production equipments as soon as they have completed their service period. Routine maintenance is divided into two types which are as follows,

(i) Running Maintenance

In this type of maintenance, the equipment machines undergoes maintenance when they are performing their operations.

Example: Applying grease or lubricating the bearings when the machine is functioning.

(ii) Shut Down Maintenance

In this type of maintenance, the maintenance work is done after the machine or equipment is shut down. Example: Servicing the boiler tubes of a boiler.

5. Planned Maintenance

Planned maintenance mainly deals with the performance maintenance activities as per the predetermined time and date (schedule). It is also called as scheduled maintenance or productive maintenance. The activities involved in planned maintenance are inspection of plants and equipments, machinery and building so that they can be repaired, lubricated and rebuild before the occurrence of actual breakdown.

The main objective of planned maintenance is to reduce the sudden breakdown of machines which will results into the stoppage of whole production system. The planned approach to maintenance plays an important role in decreasing the downtime of machine or equipment, maintenance costs and helps in improving the productivity of a process.

2.9.2 Breakdown Maintenance

Q48. Define breakdown maintenance. Explain the objectives of breakdown maintenance.

Ans :

Breakdown maintenance is made when the equipments or machines fail to perform their operations. Breakdowns need to be repaired for overcoming its consequences. Breakdown maintenance mainly deals with the equipment or machines repairs. When they becomes malfunction.

Under such circumstances, firms needs the assistance of maintenance department which examines the problem and makes the necessary repairs.

Breakdown maintenance is usually seen in the small factories because they remain passive towards the scheduling benefits and have temporary or permanent demand pattern which exceeds the normal operating capacity.

Objectives

The following are the objectives of breakdown maintenance,

1. To restore the normal functioning of an equipment by repairing it so as to minimize the production interruptions. This objective has a direct impact on production capacity, production costs, product quality and the level of customer satisfaction.
2. To supervise and control the cost of repair crews which is inclusive of regular time and overtime labour costs.
3. To manage and to reduce the operation cost of repair shops.
4. To effectively manage the investment of replacing or firing new spare parts in case of machines breakdown.
5. To use adequate amount of repairs for each breakdown. Causes of Equipment Breakdown

Equipment undergoes breakdown due to the following reasons,

1. When firms fail to replace the obsolete parts.
2. Due to the lack of proper lubrication of machines and their component parts.
3. Absence of proper cooling system.
4. Becoming passive towards the minor defects.
5. Due to not considering the impact of uncontrollable or external factors.
6. Due to ignoring equipment vibrations and unusual sounds and ignoring even if equipments are becoming abnormally hot.

Q49. Explain advantages and disadvantages of break down maintenance.

Ans :

Advantages of Breakdown Maintenance

The following are the advantages of breakdown maintenance,

1. Breakdown maintenance is highly economical for those equipments or machines whose downtime or repair cost is low.
2. The cost incurred on this type of maintenance is less when compared to the other types of maintenance.
3. It involves very less administrative work. Disadvantages of Breakdown Maintenance

The following are the disadvantages of breakdown maintenance,

1. Considerably small number of employees are able to handle breakdown maintenance.
2. Breakdown mostly takes place at an inappropriate times leading to improper maintenance and excessive delays in production. Due to these reasons, breakdown maintenance comes a difficult task.
3. Breakdown is not applicable for those plant items that are controlled by statutory provisions.

Example: Lifts, cranes, hoists and vessels

2.9.3 Preventive/Corrective Maintenance

Q50. What is reventive / Corrective Maintenance? Explain its objectives.

Ans :

Preventive/Corrective Maintenance

Preventive maintenance is usually done for reducing the frequency of plant/equipment breakdowns. Breakdowns can be prevented by cleaning, inspecting, oiling and retightening of component parts which helps in restoring the efficiency of equipments. However, preventive maintenance would be a costlier affair as for regular inspection and checking, firms need to pay huge amount to the inspection audits.

Objectives of Preventive Maintenance

The following are the objectives of preventive maintenance,

1. To attain maximum production at less repair cost.
2. To provide security to the workmen.
3. To make the plant and equipment and machinery always available so that they can be readily used.
4. To carryout inspections, repairs servicing etc., regularly for maintaining the value of equipment and machinery.
5. To preserve the operational accuracy of the plant equipment.
6. To retain the optimum productive efficiency of plant and equipment and machinery.

Q51. Explain the Features of Preventive Maintenance.

Ans :

An effective preventive maintenance program is characterized by the following features,

1. Uses repair budgets for the major equipment items.
2. Checklists are used by the inspectors.
3. Maintains precised and proper records about the volume of work, cost and scheduled date and time.
4. Administrative procedures are used for providing the basic requirements and feedback as a follow-up programme.
5. Inspections are done on definite schedule with the help of standing orders and by using specific assignments.
6. Includes well qualified inspectors who are capable of identifying the problems and making simple repairs when they are required.

Q52. What are the Elements of Preventive Maintenance.

Ans :

Preventive maintenance consists of the following elements,

1. An effectively designed inspection system.
2. Plans and planning framework for the maintenance of work.
3. Levels of inventory for all plants and equipments.
4. Well-designed and functional lubrication system involving the regular cleaning of equipment and machines, application of grease or lubricating oil by following the suggestions of instruction manuals.
5. Historical maintenance records.
6. Categorization of equipments and machines based on relative importance and priority.
7. Special inspectors and maintenance crew for preventive maintenance programme.
8. Establishment of separate provisions of standby machines for the most critical components.

Q53. What are the steps involved in a preventive maintenance programme?

Ans :

The procedure for preventive maintenance depends on the nature, type of equipments to be maintained, maintenance methods, historical record and inspection records.

The following are the steps involved in a preventive maintenance programmes,

1. Identification of Job/Development of a Facility Register

A facility register provides information about the items, machines or equipments that needs to be maintained. Through facility register, firms initiate the preventive maintenance because it gives all the details required to carryout preventive maintenance programme.

2. Development of a Preventive Maintenance Schedule

With the help of maintenance schedule, method, time and place for performing maintenance work can be known. It provides information about the availability of maintenance team and the time phasing of maintenance, loading on maintenance team.

3. Establishment of a History Card

A machine history card maintains the record of all repairs, replacement and engineering changes made on equipment or machinery during its service period. It also provides information about the frequency of occurrence of breakdown rate at which various components break, total downtime required for failure and repair of machine or equipment.

4. Development of Job Specification

Job specification is a document providing entire information about the maintenance work which needs to be done. Separate job specifications needs to be developed for the maintenance of different jobs which acts as a guide for the maintenance team

5. Preparation of a Preventive Maintenance Program

A preventive maintenance program represents the allocation of specific maintenance work that has to be performed within a stipulated time period.

6. Creating a Preventive Maintenance Schedule

On the basis of the significance of machines or equipments, their maintenance frequency can be determined. Based on this frequency, preventive maintenance schedule is created. A maintenance programme involves the following activities,

(i) Inspecting all the electrical connections of the machine or equipment.

(ii) Examining the performance of all the parts of machines or equipment.

(iii) Replacing the obsolete parts or tools.

(iv) Cleaning the interior parts like gear box, radiator etc of transport and material handling equipments.

(v) Examining the control systems.

(vi) Servicing.

7. Development of an Inspection Report

The inspection personnel inspects and observes the functioning of machines and equipments given by the inspection schedule. Their findings must be reported to the maintenance foreman for taking necessary actions.

8. Preparation of a Maintenance Report

Maintenance report is a document showing the different suggestions that were proposed by the inspectors in their inspection reports. In such reports, feedback is received from operators about the condition of the equipments or machines.

9. Feedback Mechanism

This is the final step in which actions are taken to correct and control the operations based on tfye feedback information. This corrective action serves as the basis for bringing improvements in future programmes.

2.9.4 Maintenance Issues in Service Organizations

Q54. What are the maintenance issues in service organistions ?

Ans :

Today, maintenance in Production and Operation Management (POM) does not simply mean maintaining the production machines, it is rather a broad perspective which is not only involved in minimizing short range costs but also the long-run performance measures such as return on investment, customer service, service quality etc.

The maintenance issues in service organizations includes the following,

1. Issues may arise in vehicle operating condition of service organizations such as airlines, trucking companies, package delivery services and rail roads. The companies must develop preventive maintenance programs to ensure top operating conditions of their trucks and aircraft.

2. When the unexpected failures occur, the companies should make necessary repairs of equipments and should manage the spare parts inventories.
3. Office personnel may face problems such as occasional malfunctioning of copiers, printers, computers and fax machines. To deal with these issues, secondary maintenance is essential in all organizations.
4. Lack of involvement of workers in equipment maintenance.
5. Lack of training programmes for the workers who work on the advanced technology based equipments.
6. Sometimes, the problems related to roads and highways may arise. The state highway departments must maintain these issues and should take decisions regarding how much to spend on preventive maintenance for roadways such as resurfacing and recoating. The decisions should also be made on the amount to be spent on making repairs such as fixing cracks and sinkholes and filling path holes etc.

To overcome maintenance issues, world class companies give the responsibility of repair and preventive maintenance to their workers. When the worker take this responsibility, they avoid major equipment breakdown by making repairs, cleaning, lubricating and adjusting their machines carefully. This results in the quick responsiveness of production systems to the needs of customers.

World class companies ensure greater involvement of workers in maintenance leading to the reduction of production costs, improvement of product quality and increased customer satisfaction.

The maintenance issues in world class companies are handled in the following ways,

1. The issues of inflexibility i.e., bloated inventories in world class companies is reduced by implementing Just-in- Time (JIT) systems. Production systems are subjected to machine breakdown specially when removing inventories. Therefore, JIT system is implemented to minimize the malfunctions of machines.
2. To warn against machine failure, vibration or heat, the world class companies have adopted automated process sensing and control systems to equipments of production. This way, it is possible to avoid failure of seals, gears, shafts, bearings or electronic components by shutting down the machines and carrying out preventive maintenance before the damage occurs.
3. The automation system has lead to the equipment breakdowns in many companies. To overcome this problem, companies are training and educating the workers to use automated equipment.

Exercise Problems

1. There are nine jobs, each of which must go through two machines P and Q in the order PQ, the processing times (in hours) are given below:

	Jobs (s)								
Machine	A	B	C	D	E	F	G	H	I
P	2	5	4	9	6	8	7	5	4
Q	6	8	7	4	3	9	3	8	11

Find the sequence that minimizes the total elapsed time T. Also calculate the total idle time for the machines in this period.

[Ans : A → I → C → B → H → F → D → E → G.]

2. There are five jobs (namely 1,2,3,4 and 5), each of which must go through machines A, B and C in the order ABC. Processing Time (in hours) are given below:

Jobs	**1**	**2**	**3**	**4**	**5**
Machine A	5	7	6	9	5
Machine B	2	1	4	5	3
Machine C	3	7	5	6	7

Find the sequence that minimum the total elapsed time required to complete the jobs.

[Ans : 2 → 5 → 4 → 3 → 1]

3. Find an optimal sequence for the following sequencing problem of four jobs and five machines when passing is not allowed, of which processing time (in hours) is given below:

Job	Machine				
	A	B	C	D	E
1	7	5	2	3	9
2	6	6	4	5	10
3	5	4	5	6	8
4	8	3	3	2	6

Also find the total elapsed time.

[Ans : 1 → 3 → 2 → 4]

Short Question and Answers

1. Define capacity planning

Ans :

Capacity Planning

Capacity planning deals with the estimation of both the long and short-term capacity requirements of a concern. It also provides different methods through which such requirements can be successfully fulfilled.

Capacity planning is the process of determining the production capacity needed by an organization to meet changing demands for its products. In the context of capacity planning, design capacity is the maximum amount of work that an organization is capable of completing in a given period.

Need for Capacity Planning

Capacity planning becomes essential :

1. If a company wants to bring improve-ments in its levels of production.
2. If the company decides to launch a new product in the market.

Once capacity requirements are determined the next step for a firm is to make decisions regarding the location of a facility and process technology.

2. Importance of capacity planning

Ans :

1. Capacity decisions have an impact on the ability of the organisation to meet future demands for products and Services.
2. Capacity decisions affect operating costs. It should be seen that capacity and demand requirements will be matched, which will tend to minimize operating costs. In practice, this is not always achieved because actual demand either differs from expected demand or tends to vary. In such cases, a decision might be made to attempt to balance the costs of over and under capacity.
3. Capacity is usually a major determinant of initial cost.
4. Capacity decisions often involve long-term commitment of funds.

3. What is line balancing.

Ans :

Line Balancing is the process of sequential work activities into work stations in order to gain a high utilization of labour and equipment and thereby to reduce Idle time.

Line balancing is to arrange the production line so that, there is a smooth flow of production from one work station to another. It balances the flow of production in such a way that there is no delays at any work station which will result in idle time for the next work station.

The main aim line balancing is to minimize the idle time along the line and result in optimum utilization of production resources.

The process of deciding how to assign tasks to workstations is referred to as line balancing. The task are assigned in such a way that each assembly line or production have equal time requirement. This helps to minimize idle time and high utilization of human resource and machineries. Lines that are perfectly balanced will haves a smooth flow of work. The limitation of line balancing is that there are various jobs which do not have the same duration therefore it is difficult to group all the activities of production.

4. What is facility location

Ans :

A plant is a place, where men, materials, money, machinery and equipment, etc., are brought together for manufacturing product. Plant location decisions are crucial because they commit organizations to long lasting financial, employment, a distribution patterns. As such, they deserve the careful attention of finance, personnel, marketing and other managers, as well as that of the operations mangers who manage the facilities.

Plant location is not a static decision that can be made and forgotten. Plant layout or facility layout choices follow the location decisions. They influence the type of equipment and level of technology employed, the flow of work and design of jobs, inventory levels, and other operating characteristics of the firm. Layout can be changed more easily than locations. However, they represent more of a continuing concern. In addition, they fall more directly within the responsibility of operations manager because they deal with the physical arrangement of productive facilities.

5. What is plant layout.

Ans :

Plant layout is a companion problem to facility location. The word *layout* is here used to indicate the physical arrangement of the plant and of the various parts of the plant. The layout will therefore encompass both the location of equipment within a department or shop and arrangement of departments upon a site. Which include offices, warehouses, rest rooms and other facilities associated with the total system. Thus, facility layout is the overall arrangement of machines, men materials, martial handling and service facilities and passage required to facilitate efficient operation of the production system. It integrates all aspects of production.

6. Objectives of Plant Layout

Ans :

1. Material handling and transport is minimized and efficiently controlled, so that the handling cost is minimized.
2. Bottlenecks and points of congestions are eliminated by using the line balancing techniques, so that raw material and semi-finished goods will move fast from one workstation to the other.
3. Workstations are designed and located suitably, so that there will be least resistance to the smooth flow of material and movement of men.
4. Sufficient space and proper location should be allocated to production centres and service centres.
5. Waiting line of semi-finished goods should be minimized.
6. Safe and proper working conditions are provided to avoid accidents & casualties.
7. Designed layout should provided with sufficient flexibility to accommodate future minute change in product design or change in the material specification.

7. Service Facility Layout

Ans :

Service facility layout is similar to manufacturing facility layout with few differences such as,

(a) It is more customer oriented.

(b) The seasonal demand and execution time may change in service facility layout.

(c) Customer presence creates the work flow.

Examples of service facility layouts are banks, restaurants, retailers, warehouses and offices.

Before studying the types of service facility layouts one needs to consider the following points,

1. The most important feature of services is "Diversity".
2. For each type of service, there are three dimensions i.e., standard or custom design, amount of customer contact and the combination of physical goods and intangible services.

8. Define aggregate planning

Ans :

Aggregate Planning is an immediate (annual) planning method used to determine the necessary resource capacity a firm will need in order to meet its expected demand. Aggregate planning generally includes combination of planned output, employment, sourcing, sub-contracting etc that can be planned for a period of 9-12 month. The goal of aggregate planning is to match 'demand' and 'supply' in the aggregate using mentioned combination in a cost effective manner.

Supply chains are easier to manage when demand is stationary. But when demand is seasonal, we face tradeoffs. Aggregate planning uses following 2 basic strategies or combination of both to deal with seasonal demand:

1. Level output

It's a fixed output scheme where demand variability is met by inventory, subcontracting, overtime, cross-training etc.

2. Chase demand

It's a make to order scheme where production rate is changed to meet demand.

9. Aggregate demand.

Ans :

Aggregate demand is the micro economic term that shows the relation between goods or services that are brought within a country and their prices. Goods or services purchased in the country is same as that of goods or services produced in a country. The aggregate demand comply with the law of demand which says that the people's desire to purchase goods and services increase when the prices decrease.

The aggregate demand curve is similar to the demand curve used in microeconomics. It shows the quantity demanded at each price. It describes how the quantities of goods changes, when there is a change in price. Therefore, aggregate demand curve says that gross domestic product will contract when the prices rise.

10. Master production scheduling

Ans :

The Master Production Schedule (MPS) defines the type and volume of each product that is to be produced within the planning horizon. The MPS is a detailed plan that specifies the exact timing for the production of each unit. Master production schedules are also used in scheduling various stages of production, depending on the type of operations, For instance, the MPS of make-to-order organizations deals only with end- items or final products, and not components and sub-assemblies.

On the other hand, the MPS for assemble-to-order organizations concentrates on scheduling the major components that are assembled to make a product after orders are received. MPS is based on an estimation of the overall demand for the end product A final assembly schedule is developed only when customer orders are received.

11. Define sequencing

Ans :

Sequencing is the process by which different jobs waiting at their respective workstations can be processed based on their priority. Priority or importance of jobs can be determined by applying priority sequencing rules. According to the rules, the job which needs to be completed first is processed first followed by the processing of less prioritizedjobs.

When there exists V number of jobs in a queue for their processing, then an operations manager must provide an answer to a question as to which job should be processed first? This can be answered by determining the priority of all the jobs based on the priority rules.

The term "priority" denotes the processing sequence of jobs for different machines or work centres. Processing of highest priority job is done when the workcentre or the machine becomes free.

It is very difficult to select the right sequencing rule on the basis of a single criterion as there is no universally acceptable rule which can be valid under all the situations.

12. Objectives of Maintenance Management

Ans :

Maintenance management has the following objectives,

1. To reduce the loss of productive time due to equipment failure
2. To reduce the repair time and repair cost
3. To optimally utilise maintenance personnel and equipments
4. To enhance the quality of products and to bring improvement of productivity.
5. To reduce the losses incurred due to stoppage of production
6. To reduce the frequency of accidents by regularly carrying out the inspection and repair of the safety devices.
7. To maintain all productive assets in a good operating condition
8. To extend the life of capital assets by improving their handling mechanisms.

13. Breakdown maintenance

Ans :

Breakdown maintenance is made when the equipments or machines fail to perform their operations. Breakdowns need to be repaired for overcoming its consequences. Breakdown maintenance mainly deals with the equipment or machines repairs. When they becomes malfunction. Under such circumstances, firms needs the assistance of maintenance department which examines the problem and makes the necessary repairs.

Breakdown maintenance is usually seen in the small factories because they remain passive towards the scheduling benefits and have temporary or permanent demand pattern which exceeds the normal operating capacity.

14. Objectives of Preventive Maintenance

Ans :

The following are the objectives of preventive maintenance,

1. To attain maximum production at less repair cost.
2. To provide security to the workmen.
3. To make the plant and equipment and machinery always available so that they can be readily used.
4. To carryout inspections, repairs servicing etc., regularly for maintaining the value of equipment and machinery.
5. To preserve the operational accuracy of the plant equipment.
6. To retain the optimum productive efficiency of plant and equipment and machinery.

15. Elements of Preventive Maintenance

Ans :

Preventive maintenance consists of the following elements,

1. An effectively designed inspection system.
2. Plans and planning framework for the maintenance of work.
3. Levels of inventory for all plants and equipments.
4. Well-designed and functional lubrication system involving the regular cleaning of equipment and machines, application of grease or lubricating oil by following the suggestions of instruction manuals.
5. Historical maintenance records.
6. Categorization of equipments and machines based on relative importance and priority.
7. Special inspectors and maintenance crew for preventive maintenance programme.
8. Establishment of separate provisions of standby machines for the most critical components.

Choose the Correct Answers

1. _____ refers to the smaller but more frequent jumps in the capacity. This strategy involves low degree of risk. [b]
   (a) Expansion strategy (b) Wait-and-see strategy
   (c) Sizing capacity cushions (d) None of the above
2. _____ refers to a systematic arrangement of machines in one line on the basis of sequence of operations. [c]
   (a) Fixed position layout (b) Process layout
   (c) Product layout (d) Cellular layout
3. _____ is the process of maintaining the activities which are handled before the machines or equipments fails. [d]
   (a) Breakdown maintenance (b) Routine maintenance
   (c) Predictive maintenance (d) Preventive maintenance
4. _____ mainly deals with the repairs which are made after the equipment or machine is out of order. [b]
   (a) Total productive maintenance (b) Breakdown maintenance
   (c) Preventive Maintenance (d) Planned maintenance
5. _____ is a type of layout in which the similar machines are grouped in one department. [a]
   (a) Process layout (b) Product layout
   (c) Fixed position layout (d) Combined layout
6. _____ is regarded as simple thumb rule method which helps in solving difficult problems and providing satisfying solutions to the line balancing. [c]
   (a) Linear programming (b) Dynamic programming
   (c) Heuristic method (d) Computerized line balancing
7. The capital assets (Eg. plant and Building) which the company owns during a time period is known as _____ [a]
   (a) Fixed capacity (b) Design capacity
   (c) Adjustable capacity (d) Potential capacity
8. _____ refers to the first part of the MPS which cannot be changed except in certain situations wherein the authorization will be required from the top levels of the organization. [a]
   (a) Frozen (b) Firm
   (c) Full (d) Open
9. _____ was first applied in aggregate planning by E.H.Bowman. [c]
   (a) Computer search (b) LinearTiecision Rules (LDRs)
   (c) Linear programming (d) None of the above
10. _____ is the total time consumed by the jobs on each machine. [b]
    (a) Idle time on machine (b) Processing time
    (c) Total elapsed time (d) Average flow time

Fill in the blanks

1. _____ is a process that follows capacity planning and uses medium range forecast.
2. _____ is a function of deciding the place where the plant must be located for maximizing the operating economy and its effectiveness.
3. _____ deals with the estimation of both the long and short term capacity requirements of a concern.
4. A _____ decides the quantity of each finished product which needs to be completed in each time period.
5. Breakdown maintenance is also called as _____.
6. _____ refers to the physical arrangement of plant and different parts of plant.
7. _____ is the process of determining the processing sequence of all the jobs at each work centre or machine.
8. _____ is a process of organizing the production line in such a way that the production flows from one workstation to other without any delay.
9. _____ is a production management function which deals with the routine problem of maintaining the physical plant in good working condition.
10. The term _____ means searching to determine i.e., to discover things for oneself.

ANSWERS

1. Aggregate planning
2. Plant location
3. Capacity planning
4. Master Production Schedule
5. Corrective maintenance.
6. Layout
7. Sequencing
8. Line balancing
9. Maintenance
10. Heuristic

UNIT III

Work Study & Service Management:

(a) Work study : Definition and its advantages and the various components. Techniques of methods analysis and work measurement

(b) Service Management: Nature of services. Types of Service operations-Quasi manufacturing, customer as participant and customer as product Scheduling challenges in Various service Operations, Value creation through service. Service quality, Culture and innovation

3.1 WORK STUDY - DEFINITION

3.1.1 Components

Q1. Define work study. What are the various components of work study ?

Ans : **(Feb.-21, Nov.-20, Jan.-18, Imp.)**

Work Study, deals with the evaluation of work methods and equipments used in carrying out a job, creating an optimum work method and standardizing the desired work methods. The effective utilization of work study method, helps in attaining increased productivity. Work Study, makes use of method study and work measurement to assure that, the human and material resources which are used for performing specific activities are effectively utilized.

The main aim of work study, is to help the management to make optimum utilization of human, machine and material resources for achieving the predetermined tasks/work.

According to British standard Glossary defines work study as follows: "It is a generic term for those techniques, particularly method study and work measurement, which are used in the examination of human work in all its contents, and which lead systematically to the investigation of all the factors which affect the efficiency and economy of the situation being reviewed, in order to effect improvement.

British standard Glossary defines methods study and work measurement as follows :

1. Method Study

It is the "systematic recording and critical examination of exiting and proposed ways of ding work, as a means of developing and applying easier and more effective methods and reducing costs."

2. Work Measurement

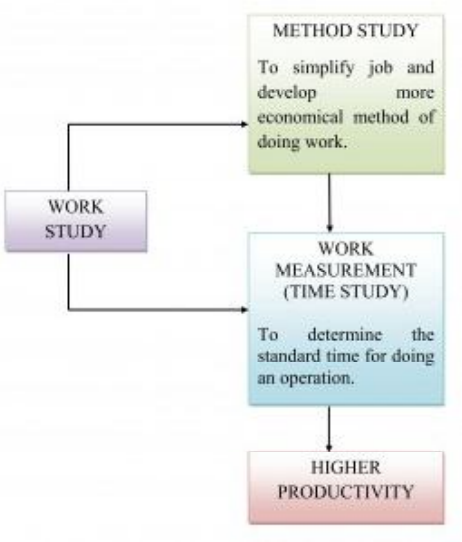
It is the "application of techniques designed to establish the time for a qualified worker to carry out a specified job at a defined level of performance."

Work Study is the systematic examination of the methods of carrying out activities such as to improve the effective use of resources and to set up standards of performance for the activities carried out.

A generic term for those techniques, particularly method study and work measurement, which are used in the examination of human work in all its contexts, and which lead systematically to the investigation of all the factors which affect the efficiency and economy of the situation being reviewed, in order to effect improvement.

Components of Work Study

Work study is encompassed by two techniques i.e. Method Study and Work measurement.



a) Method study is systematic recording and critical examination existing and proposed ways of doing work, as a means of developing and applying easier and more effective methods and reducing costs.

b) Work measurement is the application of techniques designed to establish the time for a qualified worker to carry out a specified job at a defined level of performance.

There is a close link between Method Study and Work Measurement. Method study is concerned with the reduction of the work content and establishing the one best way of doing the job where as work measurement is concerned with investigation and education of any ineffective time associated with the job and establishing time standards for an operation carries out as per standard method.

Q2. Explain the procedure for work study.

Ans :

There are eight steps in performing a complete work study. They are :

Step 1: Select the job or process to be studied.

Step 2: Record how it is performed, using the most suitable of the recording techniques, so that the data will be in the most convenient form for analysis.

Step 3: Examine the existing method critically.

Step 4: Develop an improved method, taking into account all the circumstances.

Step 5: Measure the quantity of work involved in the method selected so that standard time is calculated.

Step 6: Define the new method.

Step 7: Install the new improved method.

Step 8: Maintain the new method in practice by proper control procedures.

Table: Method study ← Work study → Work measurement.

Sr. No.	Basic Steps	Method Study	Work Measurement
1.	Select	✓	✓
2.	Record	✓	✓
3.	Examine	✓	✓
4.	Develop	✓	× or –
5.	Measure	× or –	✓
6.	Define	× or –	✓
7.	Install	✓	× or –
8.	Maintain	✓	× or –

3.1.2 Advantages of Work Study

Q3. What are the Advantages of Work Study?

Ans : **(Feb.-21, Nov.-20, Imp.)**

The following are the advantages of work study,

1. Work study helps in improving the productivity and operational effectiveness.
2. It helps in decreasing the cost of manufacturing.
3. It helps in enhancing the work place layout.
4. The use of work study method, helps in effective manpower planning as well as capacity planning.
5. Work study, helps in developing effective working conditions for the employees.
6. It helps in providing improved work flow.
7. Work study helps in decreasing the cost of material handling.

8. It acts as basis for sound incentive scheme.
9. It helps in providing fair and equal wages to the employees.
10. It helps in providing job satisfaction to the employees.
11. Work study builds good industrial relations and employee morale.

3.2 Method Study / Analysis

Q4. Define method study ? What are the Objectives of Method Study?

Ans :

Method Study is a technique of systematic recording, observing and critically analyzing the existing ways of doing work or task with the objective of enhancing the existing method and developing new and cost effective method which reduces the costs.

Objectives of Method Study

The objectives of method study can be studied as follows,

1. To examine the present method of performing any job activity or operation.
2. To create or design a method for enhancing the productivity and decreasing the operating cost.
3. To decrease the material handling or material movement, as it helps in reducing the weakness or fatigue of employees.
4. To make the optimum utilization of resources.
5. To remove the unnecessary motions.
6. To make the work methods or processes standardized.
7. To improve the work place layout of factories so that, a clean and hygienic working conditions are provided to the employees.
8. To develop improved quality of products.
9. To introduce high standards of safety and health for employees.
10. To provide greater job satisfaction to the employees.

Q5. What are the application of method study.

Ans :

Method study is not only used in manufacturing companies, but also in service sectors such as hospitals, banks, offices and various other service companies.

In manufacturing sector, the areas in which the method study can be effectively applied are as follows:

1. To enhance the procedures and methods of work.
2. To enhance the working conditions and efficiency of labour.
3. To decrease the repetitiveness in work.
4. To ascertain the optimum sequence of performing the work.
5. To enhance the utilization of plant and material.
6. To enhance the layout, by handling the How of material effectively with less bulk tracking.
7. To remove the unproductive or inefficient operations.
8. To decrease the cost of production, by decreasing the cycle time of operations.

Q6. Discuss the various steps involved in method study?

Ans :

The following are the steps involved in method study:

1. Selecting the Work

The first step involved in method study, deals with selecting the work or job, that needs to be studied and formulating the objectives, that must be achieved. The job which is selected should, have greater economic advantage and provide wider scope for enhancing the work, by reducing excessive material handling and making effective utilization of resources.

2. Recording the Information

In this step, all the significant information related to the present method is recorded using various recording techniques like:

(a) Process Charts: It consists of the following charts,

(i) Operation process chart
(ii) Outline process chart
(iii) Flow process chart
(iv) Multiple activity chart
(v) Two handed process chart
(vi) Man-machine chart
(vii) Motion chart
(viii) Firm analysis chart
(ix) Simultaneous motion chart (SIMO chart)

(b) Diagrams: It includes the following techniques,

(i) String diagram
(ii) Flow diagram
(iii) Cycle graph
(iv) Chronocycligraph.

3. Analyzing the Facts/Information

This step deals with the analysis of recorded information and the tasks performed and determines the alternatives, examines what has been achieved, the way it has been achieved, when it has been achieved, the place where it is achieved and the individual who is responsible for attaining it.

4. Develop

In this step, an improved method is developed, by evaluating various alternatives and selecting the best method among them. While assessing and selecting the best method, the following factors must be considered:

(a) Cost involved in implementing the method.
(b) Savings that can be made in time and cost.
(c) Feasibility.
(d) Producibility of the method.
(e) Design acceptance to production planning and control, quality control production and sales departments.
(f) The response of employees towards the new method. A new method is developed by arranging appropriates equipment design, technological aids, jigs and fixtures, tools working conditions, office layouts and control techniques.

5. Install

This step deals with the installation of new method. The new method is installed in three different phases: Planning. Organizing, and Implementing. The first two phases involve the planning of installation program and a schedule and the various requirements like, equipments, resources etc., are provided to the workers. The third phase is the implementation phase in which, the new method is introduced as standard practice for attaining the planned results.

6. Maintain

This is the final step of the Method Study procedure in which, the new method is sustained by assuming that it is functioning effectively. This is done by checking and verifying the new methods regularly. Appropriate control procedures are used, for assuring that the use of new method helps in attaining the benefits of methods study.

3.2.1 Techniques of Methods Study

Q7. What are the techniques of method study?

Ans : **(Nov.-20, Jan.-18, Imp.)**

Method Study

The different recording techniques used in method study are as follows,

1. Process charts
2. Diagram

These techniques are explained in detail below.

1. Process Charts

These charts help in providing a complete picture of the process. A chart which shows or describes a process is called as a Process Chart. Process charts consists of the following charts:

(a) Outline Process Chart

An Outline Process Chart, examines and records the complete picture of the process and outlines only the important events sequentially. The main operations and inspections are considered in this chart.

(b) Operation Process Chart

This chart graphically represents the points at which the materials are introduced in the process, the order of inspections and all operations (excluding the operations involved in materials handling). It includes the relevant information for estimation such as, the time needed for performing the operation and the location or place.

(c) Flow Process Charts

These charts, graphically represent the order in which all the operations, transportation, delays and storages takes place during the course of process. It includes the information used for assessment such as the time needed and distance covered.

(d) Two Handed Process Chart

The hands or limbs activities of workers or operations are recorded chronolo-gically in the two-handed process chart.

(e) Multiple Activity Chart

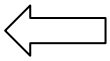
The Multiple Activity Chart, records the activities of more than one subject, i.e., worker, equipment or machine a common time scale, for outlining their inter-relationship.

(f) SIMO Chart

This chart is a type of two handed process chart, which records the small motions of both the hands.

(g) Man Machine Chart

The charts are usually denoted by symbols, which provide a clear picture and helps in understanding different facts effectively, a five types of symbols are used for recording various types of events. These symbols are as follows:

S.No.	Symbol	Activity	Purpose
1.		Operation	This event deals with the change in the location or product conditions.
2.		Transport	This event represents the movement of items such as materials equipment etc., from one place to other place.
3.		Inspection	This event involves the evaluation of the quantity or quality of items.
4.		Delay	Delays takes place when the process stops due to some reason and the product has to wait for the next event.
5.		Storage	Storage denotes the objects which are retained for sometime for the reference purposes.

(h) Man Machine Chart-Worker Machine Chart

This chart is a type of multiple activity chart, which shows the operations and delays occurred by the operators while operating the machine.

2. Diagram

Diagrams clearly outlines the movement of men and materials between two locations and the number of times a movement is repeated.

In a repair shop, or overhauling shop or other departments, movement of men and materials occurs from one place to another place. The process charts represents the order of events, but does not shows the movements of material, men etc. Reducing these movement helps in saving the cost and efforts needed for performing a job.

The movement of men and materials between two locations and the number of times the movement is repeated can be illustrated, with the help of diagram. There are two types of diagrams:

(i) Flow diagram

(ii) String diagram.

(i) Flow Diagram

The flow diagram is a diagram, illustrating the position of jigs, fixtures, production machinery etc. The movement followed by the workers and materials are also marked in the flow diagram. The flow diagram is suitable for simple cases.

(ii) String Diagram

If there are several repetitive paths, then a flow diagram becomes crowded and it becomes difficult to trace and understand. In such type of situations string diagram is used.

A String Diagram, is a model wherein, each machine is marked and a pin or peg is placed in the area which represents a facility. A string helps in identifying the movement followed while performing a particular operation followed by men and materials. A string diagram is used, for handling the difficult or complex movement shows layouts of plant and design problems. It clearly shows the over and under-utilized paths on the shop-floor, estimates the distances involved and detects the current path of movements for making required changes.

A String Diagram is suitable for movements which are irregular with regard to their frequency and distance covered. It indicates the pattern of movements, which assets in selecting the most economical routes for performing a job or a particular operation.

3.3 WORK MEASUREMENT

Q8. Define work measurement? State the Objectives of Work Measurement?

Ans : **(Aug.-21, Dec.-18, Imp.)**

Work Measurement

Work measurement is also called time study. Work measurement is absolutely essential for both the planning and control of operations. Without measurement one cannot determine the capacity of facilities and costs.

Objectives of Work Measurement

The use of work measurement as a basis for incentives is only a small part of its total application. The objectives of work measurement are as follows:

1. Comparing alternative methods.
2. Manpower requirement planning.
3. Planning and control.
4. Realistic costing.
5. Financial incentive schemes.
6. Delivery date of goods.

Q9. Explain the terms used in Work Measurement.

Ans : **(Sep.-22, Dec.-19, Imp.)**

Work measurement divides an operation into simple activities and allots a time value. It is usually, performed after method study, to avoid disputes between management and union. Effective work measurement produces useful information, which helps in optimum utilization of labour, production schedule, standard costing, budgeting and identifying competitive pricing of products.

The main objective of work measurement is to ascertain the allowed time for a qualified worker, for carrying out a task through a specified method under a given set of conditions. Work measurement can be used effectively, for managing incentive schemes in an organization.

The following are the terms used in work measurement:

1. Standard Performance

It is optimum rate of output that can be achieved by a qualified worker as an average per working day or shift, due allowance being made for the necessary time required for rest.

Who has necessary physical attributes, education, intelligence, skills and knowledge to carry out the specified work to the satisfactory standards of quality, quantity and safety.

2. Element

An element is a distinct part of a specified job. These are of eight types, viz. Repetitive, Occasional, Constant, Variable, Manual, Machine, Governing and Foreign.

3. Work Cycle

It is the sequence of. elements are required - to perform a job or yield a unit of production.

4. Rating

Rating is the assessment of a worker's performance level relative to the observer's concept of the norm of the expects performance for effective economy of a labour.

5. Standard Rating

It is defined as the rate of output which qualified workers will naturally achieve as an average output for a given period of time. This rating is denoted as 100.

6. Basic (Normal) Time

Time is the time taken by a qualified worker to do a piece of work at the standard rate of performance.

Basic time = Observed time x Rating factor

= Observed time x (Observed rating H-100)

7. Relaxation Allowance

It is the additional time that is allowed to a worker for a specified work over and above the basic time.

This time is allowed so that he can recover from physical fatigue and stress due to the job and also for attending to his personal needs.

It is computed as a percentage of basic time and taken into account several factors depending upon the job.

8. Work Content

The work content of a job consist of work plus allowance for rest, personal needs, contingencies and so on, given in work units, viz.

Work content = Basic time and relaxation allowance and any other allowance for additional work, viz. that part of the contingency allowance which represents work.

9. Standard Time

It is the total time in which a job should be completed at standard performance.

Standard time = Basic time + Allowance

10. Allowed Time

The total time allowed for the completion of a work or task including time for personal needs, rest and unavoidable delays.

11. Standard Minutes

A standard minute (SM) expresses a unit of work in terms of the 100 BS scale. Standard performance is recognized as being 60 SMs an hour. It is different from standard time, in that the latter includes ineffective and unoccupied time.

Q10. Explain the Procedure for Work Measurement

Ans : **(Dec.-19)**

Step 1: SELECT the job to be measured. The select job is broken down into its elements. This division helps to separate productive from unproductive work. The also facilitates the determination of the rate of performance.

Step 2: RECORD the relevant data relating to the jobs, the elements into which the job is broken down, the method used etc.

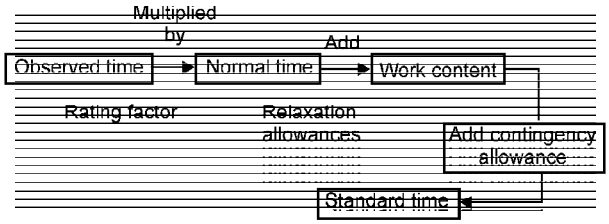
Step 3: EXAMINE the recorded data to eliminate unproductive and foreign elements thus ineffective time.

Step 4: DEFINE precisely the series of activities and the method to be used.

Step 5: MEASURE the quantity of work involved using appropriate work measurement techniques.

Step 6: Estimate normal time. Assess relaxation allowance for personal needs and mental and physical fatigue.

Step 7: Add relaxation allowance, contingency allowance and other allowances if any to normal time to get standard time.



3.3.1 Techniques/Methods of Work Measurement

Q11. What are the techniques/methods of work measurement ?

Ans : **(Sep.-22, Aug.-21, Dec.-19, Dec.-18, Imp.)**

The following are the techniques of work measurement :

1. Time study
2. Work - sampling
3. Synthesis from Standard data
4. Predetermined Motor-Time systems.
5. Analytic estimating techniques

1. Time Study

Fedric W.Taylor developed the concept of Time Study. (Stop watch method in 1881). It is the most commonly used work measurement method in industry all over the world. According to this method standard time and Normal time estimates of a job are determined by making physical observations, with the help of a mechanical device like stop watch or video camera.

Time study is defined by ILO (International Labour Organization) as "Work Measurement technique for recording the times and rates of working for the elements of a specified job carried out under specific conditions, and for analyzing the data so as to obtain the time necessary for carrying out the job at a defined level of performance."

Time Study Equipment

The following equipment is required to carry out a time study analysis.

- A stop watch
- A study board
- Time study forms
- A calculator
- A reliable clock with a seconds hand e Set of measuring instruments like tape, steel rule, micrometer, spring balance, tacho-meter (measures rotational speed) etc.
- Cine camera equipment and accessories, with variable speed attachment.

Objectives of Time Study

i) To establish, by direct observation, the quantity of human work (work content) in a specified task.

ii) To estimate and establish standard time required to perform a work task by an average worker, working at a normal pace.

iii) To determine basic or normal times for performing various job elements.

iv) To establish labour standards for satisfactory work performance.

v) To provide a basis for determining operational efficiency.

vi) To compare the work efficiency of different operators.

vii) To furnish a basis for comparison of a available alternative methods, in method study in order to select the best method.

viii) For Man power planning

ix) To provide a basis for setting wages and incentives

x) To arrive at job schedules for production planning purposes.

xi) To determine the cycle time for completion of a job.

Advantages of Time Study

The advantages of time study are as follows:

i) Time study estimates the normal time and standard time accurately, by using the stop watch.

ii) It helps in fixing the price rates and incentive wages.

iii) Time study methods develop a complete time table about the completion of individual operations or jobs.

Disadvantages of Time Study

The following are the disadvantages of time study,

i) It is uneconomical to use a stop watch.

ii) Limited activities can be measured with the help of stop watch.

iii) It is very essential to have an expert work analyst for operating the stop watch.

iv) A degree of subjectivity is involved in the Time Study method, while selecting the individuals who will be analysed for ascertaining the standard time.

Uses of Time Study

Time study ensures reliable and constant standard of performance which is useful for different aspects such as,

i) For making wage payments

ii) To make incentive payments

iii) Ascertaining planned and schedule operations.

iv) Ascertaining standard cost which is helpful in preparing budget.

v) Evaluating costs involved in the project, before manufacturing, as it is useful for bids and for determining the selling price.

vi) Helps in ascertaining the effectiveness of machines such as, how many machines can be operated by a single person, required personnel in the form of group in balancing assembly lines and work performed on a conveyor.

2. Working Sampling

Work Sampling : It is a method of finding the percentage occurrence of a certain activity by statistical sampling and random observations.

In this method large number of random observation are made over a specified period of time on a group of workers, machines and process.

Procedure for Activity Sampling

Activity sampling involves the following steps:

i) Planning

This step deals with initial planning in which, the work to be timed, the expected accuracy limit (A) and the confidence level is selected.

ii) Pilot Study

The pilot study is done, before the actual study for identifying the value of *'X'* and for controlling the minimum number of observations (5) from the formula,

$$S = \left(\frac{G}{A}\right)^2 \times (100 - X)$$

Where, the value of X is mentioned in percentage.

iii) Actual Study

After the pilot study, the actual activity is performed wherein, the minimum number of observations (5) are performed based on the figure obtained in step 2. This provides the results for the expected confidence level. After conducting S observations, the mean value for given G-value is determined, with the help of following equation, the standard error is determined.

$$A = \pm G \sqrt{\frac{X(100 - X)}{S}}$$

After identifying the standard error, the range of 'X' is determined that is,

$X_{max} = (X + A)$.

$X_{min} = (X - A)$.

iv) Basic Time (BT)

The basic time is determined from the mean value of 'X' with the help of following equation:

BT = X × O Where,

O = Total time taken for operation

X = Percentage of total time utilized for the work.

Based on the maximum and minimum value of X, the basic time also varies between maximum and minimum limits.

v) Standard Time

The final step in activity sampling method is the calculation of standard time. It is calculated with the help of the following equation:

ST = BT + R.

Where, R stands for allowances.

3. Synthesis Techniques

In many industries product is product in large numbers or in batches of varying sizes at irregular intervals. And this is done by operations which are frequently uses in the factory. In such cases time study techniques can be avoid. It is appropriate to use synthetic techniques where standard time is computed by adding various elemental times , which constitute the work.

Standard data is made available for most of the known elemental operation such as for setting, preparatory, tool positioning, holding, tightening, manipulating, removing and clearing. This data is stored in a library for reference when requires for estimating scheduling or any other function.

The data of one factory cannot be applicable to other factories, because the functions and conditions of one factory is different from that of other.

Advantages of Synthesis Technique

The following are the advantages of synthesis technique

i) Synthesis Technique is an efficient and reliable technique, as the formulated time values of the standard data catalogue are basically derived from several time studies.

ii) Synthesis Technique is economical, as it consumes less time when compared to the 'stop watch' time study.

iii) It helps in predicting the labour times, which are used in formulating the expected cost for new jobs on which the selling price has to be estimated for customers.

Applications of Synthesis Method

The following points help us to know the applications of synthesis technique:

i) Synthesis technique is used for predicting the production or manufacturing time of a product for ascertaining the selling prices of the products.

ii) It acts as a basis for formulating and designing various incentive schemes.

iii) It is used for predicting the expected standard time for new jobs.

4. Predetermined Motion Time System (PMTS)

PMTS is a work measurement technique whereby times established for basic human motions (classified according to the nature of the motion and the conditions under which it is made) are used to build up the time for a job at a defined level of performance.

a) Select large number of workers doing varieties of jobs under normal working conditions in industries.

b) Record the job operations on a movie film. (Micromotion study).

c) Analyse the film, note down the time taken to complete each element and compile the data in the form of a table or chart.

The jobs selected are such that they involve most of the common, basic motions and are worked under different set of conditions by workers having different ages and other characteristics.

Once the table for various basic motions are ready, the normal time for any new job can be determined by breaking the job into its basic movements, noting time for each motion from the tables and adding up the time values for all the basic motions involved in the job. Standard time may be obtained by adding proper allowances.

Types of Predetermined Motion Time Systems

The following are the different types of PMTS,

i) Methods Time Measurement (MTM)

Under this method of PMTS. predetermined time values for basic motions (human motions such as turn', 'move', 'reach' etc.,) are determined in the form of Time Measurement Units (TMU's) where,

One TMU = 10^{5} hour or 0.00001 hour or 0.0006 minutes or 0.036 seconds.

ii) Work Factor

This method of PMTS. depends on basic human motions, which are altered or modified elements of difficult nature that results in slow movement. These features or work factors include, weight or resistance, manual control, change of direction, need for care and stopping a motion. These features or work factors tend to change the basic time values.

iii) Basic Motion Times

BMT is also dependent on basic human motions where, times are derived from practical experiments and are examined carefully over different factory or industrial operations before making it as a standard to use.

Advantages of PMTS

The advantages of PMTS can be studied as follows:

i) PMTS helps in analysing and improving the work methods effectively.

ii) It is the most effective and economical technique of work measurement for similar and repetitive jobs of shorter time period.

iii) It does not involve any interruption in the normal routine work, so it faces less resistance from the workers.

iv) PMTS accurately records the time, by ignoring the individual justification or bias of the rater.

v) As the basic motion time is decided in advance, the calculation of standard time for a job is easier and economical, when compared to stop watch time study.

Disadvantages

The following are the disadvantages of PMTS,

i) The standards for basic human motions are unavailable for each and every activity.

ii) It has limited application in office and non responsive activities.

iii) For using PMTS. It is very essential to spend adequate time for conducting intensive training under expert guidance.

iv) It is applicable and restricted only to uncontrollable work. It does not consider the work which does not involve the motions.

5. Analytical Estimation Techniques

It is a work measurement technique using a development of estimating, whereby the time required to carry out elements of a job at a defined level of performance is estimated partly from knowledge and practical experience of elements concerned and partly from synthetic data.

Procedure of Analytical Estimation

(a) Find out job details which include job dimensions, standard procedure and especially the job conditions i.e., poor illumination, high temperatures, hazardous environments, availability of special jigs, tools, material condition.

(b) Break the job into constituent elements.

(c) Select the time values for as many elements possible from the library of element time values (i.e., synthetic data).

(d) To the remaining elements for which no synthetic data is available, usually the estimator gives suitable time values from his past knowledge and experience.

(e) Add (c) and (d) and this is the total basic time at 100% rating.

(f) Add to (e) an appropriate blanket relaxation allowance (to whole job and not individual elements).

(g) Any additional allowances if applicable may be added to (f) in order to arrive at standard time for the given job or task.

3.4 SERVICE MANAGEMENT

Q11. Define services

Ans :

Services can be defined in the following ways,

1. "Service is an identifiable, intangible activity that is the main object of a transaction designed to provide satisfaction to the customers".
2. Services include "All economic activities whose output is not a physical product or construction, is generally consumed at the time it is produced and provides added value in forms (such as convenience, amusement, timeliness, comfort or health) that are essential concerns of its first purchaser.
3. The American marketing association defines services as "services are the activities, benefits or satisfaction which are offered for sale and provided in connection with the sale of goods".
4. Services are "Economic activities that produce time, place, form or psychological utilities".
5. A service is an act or performance offered by one party to another. Although the process may be tied to a physical product, the performance is intangible and does not normally result in ownership of any of the factors of productions.

3.4.1 Nature of Services

Q12. Explain the nature of services.

Ans : **(Aug.-21)**

Nature of Services

There are four distinctive characteristics of services which create special marketing challenges. These characteristics of services are discussed as 4I's of services. The 4I's of services are as follows,

1. Intangibility of services
2. Inconsistency of services
3. Inseparability of services
4. Inventory of services.

1. Intangibility of Services

Services have no physical attributes which makes it difficult to feel, taste, hear or smell before they are bought. The customers are made to buy services on trust.

2. Inconsistency of Services

Inconsistency of services is variability or heterogeneity of services i.e., service provided may differ from time to time. The customer preference in availing a service and the service provided by individuals also vary.

3. Inseparability of Services

Production and consumption of services takes place simultaneously i.e., cannot be separated. For example, a dentist creates and

delivers the services simultaneously and the presence of consumer is required during the performance of the service.

4. Inventory of Services

Services cannot be stored, saved or inventoried. This perishable nature of services creates so many problems. For example, a plane takes off with thirty empty seats, forever loses the opportunity to sell those thirty seats though the expenses for the flight are same as they would have been, if the plane would have been filled.

3.5 Types of Services Operations

Q13. Explain the various types of services operations.

Ans : **(Aug.-21, Dec.-19)**

The different types of service operations are,

(i) Quasi-manufacturing service operation.

(ii) Customer-as-participant service operation and

(iii) Customer-as-product service operation

(i) Quasi-Manufacturing Service Operation

The production in quasi-manufacturing service operation is much more when compared to manufacturing. It focus on the cost of production, tangible materials and products, quality of the product, timely delivery and technology. The physical products either custom or standard have low level customer contact or involvement

Example: Aircraft maintenance, industrial heat treating services, back-room operations at banks etc. are few examples of quasi-manufacturing service operation.

(ii) Customer as Participant

In this type of service operation, there will be high level of customer contact or involvement. These services may be either custom (or) standard and the tangible goods may or may not be an important part of this service.

Example: Retailing.

(iii) Customer-as-Product

In this type of service operation, there will be high involvement of customer and it is actually applied on the customer. Here, the services are custom in nature and the tangible goods may or may not be an important part of this service.

Example: Medical clinics, Hospitals, Saloons and Tailors etc.

It is necessary to know that the classification of these service operations are not mutually exclusive. Finding all the three types of service operations within the company is a common thing. Atleast two service operations are usually seen in one company.

Example: McDonald's restaurant is having a successful quasi-manufacturing service operation in back room and customer-as-participant service operation in front room. Banks, restaurants, libraries, repair shops and laundries are also having both quasi-manufacturing service operation in back-room and customer-as-participant service operation in front room. As manufacturing business have process-focused and product-focused operations working simultaneously, one or more service operations may be found within the manufacturing unit.

3.5.1 Quasi-manufacturing Service Operation

Q14. What is product focused and process focused Quasi - manufacturing service operations ?

Ans : **(Sep.-22, Feb.-21, Dec.-18, Imp.)**

"Quasi-manufacturing service operations are different from other service operations because there is no involvement of customers in production. Due to this, the practical application of quasi-manufacturing is same as manufacturing operations." Same as manufacturing operations, service operations are designed, planned, controlled, scheduled, analyzed and managed. Quasi-manufacturing service operations may be either process- focused or product-focused operations.

Product-Focused Operations

In manufacturing business, few service operations are similar to product-focused production lines.

Example

Let us consider the back-room operations in McDonald's restaurant. Just as in manufacturing, following activities are done in the service operations. They are,

(i) Equipments, workstations and buildings are designed and laid-out.

(ii) Meeting point is equated.

(iii) Automation and technological issues are taken into account and examined.

(iv) Decisions are made regarding the forecasting of demand and capacity of production.

(v) Employees are recruited, trained and supervised.

(vi) Materials, hamburger buns, paper boxes, patties etc, are purchased, ordered for delivery and inventoried by considering the costs and demand.

(vii) Based on the combination of produce-to-stock and produce-to-order high quantity of standardized products are manufactured.

(viii) Control of production costs, quality of product and prompt delivery of tangible goods are similar to management's objectives in manufacturing business.

(ix) The achievement of management objectives are assessed and examined.

Some of the service operations are also the product focused quasi-manufacturing service operations.

Example

The life insurance policy writing process at the headquarters of insurance company.

Process-Focused Operations

Most of the manufacturing operations and process- focused operations comes under quasi-manufacturing services operations.

3.5.2 Scheduling Customer-as-Participant Service Operations

Q15. Write about the nature of customer-as-participant service operations.

Ans : **(Sep.-22, Feb.-21, Dec.-18, Imp.)**

Customer-as-participant is one of the service operations where the level of customer involvement is very high because of actual participation of customers. Retailing which includes customers shopping, selecting, paying, for carrying, physical goods comes under service operations. As customers take part in these operations, the facility design must consider customer needs. The features of these operations are,

(i) Well-organized and lighted packing areas or garages.

(ii) Well-designed walkways to carry people to and from packing areas.

(iii) Easily located entry ways are designed so that large number of customers can easily accommodate during peak hours.

(iv) Escalators and powered doors are designed to reduce the efforts of climbing stairs and opening doors.

(v) Lobbies for customer, service counters, customer waiting lines, employees workstations, cash register, aisle ways, attractive decors etc.,

The provided features differs with the level of customer involvement in operations. For example, the bank's front-room operations are designed for customers with parking facility, good waiting lines, easy entering and exiting facilities individualized areas for customer savings account and loan customer servicing etc., The front room at McDonald's retail department stores such as Wal-Mart, and D-Mart are some of the examples of customer-as-participant service operations.

The management and layout of these operations need close cooperation. The activities which are managed by the operations managers are inventory planning and control, product quality of physical goods, scheduling of personnel, planning for waiting lines, warehousing, shipping, purchasing etc.,

However, the objectives of these operations are influenced by customer satisfaction and product quality. To maximize customer satisfaction, forecasting facility layout, evaluation of automation and computer in operations, capacity planning inventory ordering and stocking policies and personnel selling are required.

In customer as participant service operations, the major concern of customers and operations managers is waiting lines of customer.

3.5.3 Scheduling Customer as Product Service Operation

Q16. Write about scheduling customer as product service operation

Ans : **(Sep.-22, Feb.-21, Dec.-18, Imp.)**

In customer-as-product service operations, service is performed on the customer where the customer is regarded as the product service operations. Hair salons, medical clinics, tailors etc comes under customer-as-product service operations. Hair salon is an example of less complex customer-as-product service operation. Here, customers are provided with different services such as shampoo and hair set, conditioning treatments haircuts, manicures etc. The customers pay and exit after receiving these services. The service operations are designed, planned, controlled, analyzed and managed with the objective of satisfying the customers.

The factors which combinedly helps in creating satisfied customers are,

(i) Extrinsic quality of the services.

(ii) The comfortable, convenience and atmosphere provided to customers.

(iii) Friendliness and politeness between customer and people in the service system.

(iv) Personnel with skill, competence and professionalism and

(v) Value of service in relation to benefits received.

In customer-as-product service systems, the personnels are considered to be main source of satisfying customers on daily basis. The personnels are hired, trained, supervised, evaluated and rewarded. The feedback from customers relating to perceived quality of services helps in acquiring effective workforce which provides high levels of customer service. These feedback helps in attaining two objectives. Firstly, the customers perceive that the companies focus on thinking and wants of satisfied customers. Secondary, regular feedback helps in further improvement of operations.

Waiting-line analysis is an important approach which helps in finding the number of personnel required to schedule during the day in performing operations. Hospitals are the examples for more complex customer-as-product services operation. The main objectives of hospitals are cost effectiveness, friendly and courteous relations with patients, providing effective medical treatments and procedure for patient that satisfy the customers enormously. The hospitals emphasize much on technological effectiveness as they are well designed and planned and use process layouts and suitable techniques.

Facility capacity, location and layout are applicable which can minimize the total distance travelled by patients and customers. In case of scheduling customer-as-product service operations with process layouts, the various approaches and manufacturing operation scheduling are used. The various approaches which are helpful are, input-output control, Gantt Charts, changeover costs and minimizing flow time.

Hence in complex service operations, the computer simulation is a useful tool which helps in scheduling personnel and other resources.

3.5.4 Scheduling Challenges in Various Service Operations

Q17. Discuss in detail scheduling challenges in various service operations.

Ans : **(Sep.-22, Feb.-21, Dec.-18, Imp.)**

The scheduling challenges involved in different service operations are,

(i) The services which are produced and delivered by different people like men, women, workers, or all human resources.

(ii) The structure of demand for services are not uniform because the demand for services

differs from hour-to-hour, day-to-day and week-to-week in a year. However, the main challenge under this is to change the production capacity in order to satisfy the changing structure of demand. In most service organizations, making variation in the size of workforce is considered as the key strategy for rapidly changing production capacity.

Addition to this, the uniform demand can also be sorted out when operations managers work harder to modify the size of the workforce that may balance the costs of productions and customer satisfaction. There may be certain strategies to deal with non-uniform demand in an service organization. They are as follows,

(i) Initiate preventive measures that results in uniform demand.

(ii) Different strategies can be used to have flexible service operations, where the production capacity can be increased or decreased based on the changes in demand.

(iii) The demand patterns are anticipated and the number of employees are scheduled to attain the anticipated demand.

(iv) The waiting lines are permitted only when customer demand exceeds the production capacity.

Apart from these strategies, many other strategies are developed that are used to calculate demand and to make it uniform. Some of the common strategies used by service organization are as follows,

1. Off Peak Incentives

The off-peak incentives helps in motivating customers to move their demand for services from peak hours to off-peak hours. For example, telephone companies ; which offers low rates for calls made on weekends etc.

2. Appointment Schedules

In appointment schedules, customers are scheduled for appointments that results in decrease in customers ; waiting time and helps the service to have a uniform production capacity.

3. Fixed Schedules

Airlines have fixed departure schedules. However, there are various ways of making flexible service system, where the production capacity can be increased or decreased on the basis of changing customer demands for services. Part-time workers, sub contractors and in-house stand by facilities can be used some of the ways to increase production capacity in peak demand periods. In emergency service operations like ambulance and lire lighting services, workers must be scheduled hour-to-hour in order to provide services at the time of emergencies. Thus, many companies permits to form waiting lines whenever the demand goes beyond the production capacity.

3.6 Value Creation through Services

Q18. Explain value creation through services.

Ans : **(Jan.-18)**

From an operations management perspective, there are four general dimensions of customer value i.e, time, quality, cost and flexibility. Time includes aspects such as speed, reliability of delivery and rapid development of a service. Quality captures both tangible and intangible features relating to service design and consistency. Similarly, | flexibility incorporates the elements that can be seen by customers and the final dimension 'cost' cannot be measured directly by customers rather it is translated by competitive forces into price.

From a customer perspective, the two primary elements of value are,

1. Utility (or) Fitness for Purpose

Customer perceives utility from the service attributes that have a positive impact on the performance of tasks linked with desired outcomes. A customer may also perceive removal or relaxation of constraints on performance as a positive effect.

2. Warranty (or) Fitness for Purpose

A warranty is a positive effect available when required in enough capacity or magnitude in terms of security and continuity.

Utility is what the customer gets and warranty is how it is delivered. It is not possible for the customer to get benefited from something which is fit for purpose but not fit for use and vice versa. Therefore, it is essential to separate the logic of warranty for design, development and improvement purposes. The following figure represents the logic of value creation through services,

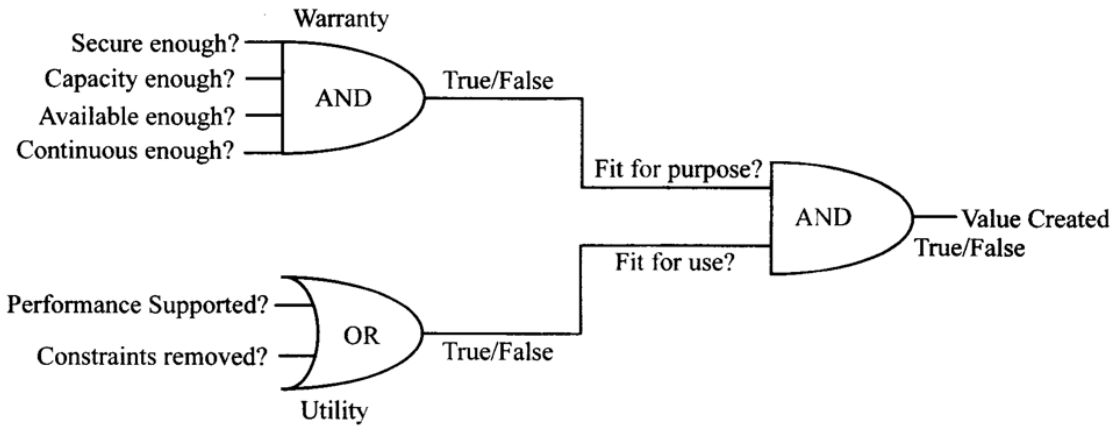


Figure: Logic of Value Creation through Services

From the above figure it can be observed that all separate inputs are given for a variety of solutions to the problems of creating, maintaining and increasing value. For instance, consider a business entity that is making use of high performance online storage service. The business concern not only looks for functionality of online store but also the easy access to not less than one terabyte of fault tolerant storage whenever required. Apart from this, the business also expects integrity, confidentiality and availability of data.

Therefore, it is necessary for the business concerns to understand their customers and their needs as to provide the valuable customer service. Every detail of customer needs and requirements should be taken into consideration without cutting comers. Today, Warby Parker is one of the best brands that provides great customer service. The company not only provides effective service but also creating value for the brands and shareholders.

A company reputed for great customer service may charge more than a company that does not have a good reputation. Four season is one such brand which has an exceptional reputation for its quality of customer service. Successful innovators and innovative organizations have a good idea of how to use customer service to create value. They create value by being honest and genuine towards the service/ product they are providing.

3.7 SERVICE QUALITY

Q19. Define service quality ? What are the dimensions of service quality ?

Ans :

According to Phillip B. Crosby, "Quality is conformance to requirements." According to Parasuraman and Berry, "Quality is exceeding what customers expect from the service.

According to Garvin, quality can be defined from different perspectives

1. User-based
2. Product-based
3. Manufacturing-based

4. Value-based and
5. Transcendent view

1. User-based approach

This approach suggests that quality should be defined from the customer's perspective. A service offering that meets the customer's needs and wants to his complete satisfaction is quality service. This approach also recognizes that different customers have different needs, because of which it becomes difficult for the service provider to satisfy every customer's needs.

2. Product-based approach

This approach suggests that the service offered by an organization falls short of the quality standards only when a certain attribute or aspect of service is left out or distorted.

3. Operations-based approach

This approach suggests that the quality of a service depends on the efficiency of the operations involved in service design and delivery. It emphasizes cost effectiveness and productivity rather than customer needs and preferences.

4. Value-based approach

This approach seeks to define quality as the value offered in return for the price paid by the customer. In other words, it suggests that the higher the price charged from the customer, the more should be the benefits offered by the service provider.

5. Transcendent view of quality

This approach suggests that a person can assess the quality of a service accurately only when he is exposed to it repeatedly.

According to Berry and Parasuraman, service quality is determined by customers using various criteria like credibility, security, access, communication, tangibles, responsiveness, competence, reliability, etc. The authors identify similarities among some of these criteria and therefore, consolidate them in to five dimensions – Tangibles, Reliability, Responsiveness, Assurance and Empathy.

- **Tangibles:** Service is intangible to customers. However, they assess the service by the equipment used to provide the service, the premises within which the service is offered and employees who provide the service. Therefore, service providers need to ensure that they provide the right ambience and infrastructure to the customers and that their smart and pleasant employees offer high quality service. Managing tangibles like these enables organizations to make a positive impression on not only existing customers, but also on perspective and first-time customers.
- **Reliability:** The service offered by an organization needs to meet the expectations of customers consistently. It is only then that a customer considers the service reliable and organization dependable. Services should be tested for their consistency before they are launched. For example, there should be proper communication systems in place and the employees should be trained in technical skills and service skills to provide high quality service.
- **Responsiveness:** Service personal should be prompt in attending to customers and serving their requirements. The customers should perceive them to be enthusiastic and responsive while serving them. The personnel should be especially attentive during problem situations where the customer has some complaints with the service.
- **Assurance:** Service personnel should have a through knowledge of the service they are providing to the customers. For example, a sales executive selling mutual funds should have complete knowledge of the expected returns and the tax implications of the investment. He should be able to provide strong and timely advice to his customers.
- **Empathy:** The service personnel of an organization should be easily accessible and open to communication. They should emphasize with customers who report problems and work quickly to resolve them.

Q20. Explain the gap model of service quality ?

Ans :

Customer gap is the difference between customer expectations and perceptions. The following figure depicts the gaps model of service quality,

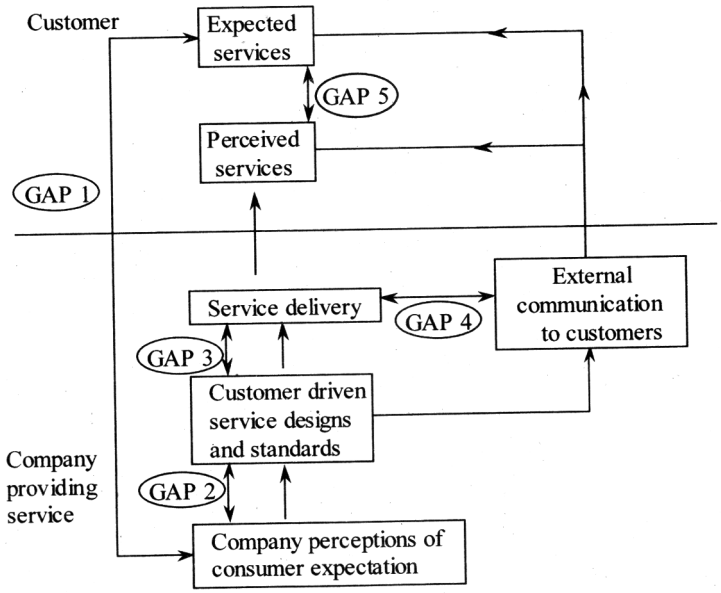


Fig.: Gaps Model of Service Quality

Consumer expectations are standards or reference points for performance against which service experiences are compared.

Example

When travelling in an A.C compartment of the train, you expect a certain level of service, that is considerably different from the level you may expect in a first class compartment.

Perception reflect the service as actually received. This is a subjective assessment of actual service experienced.

The objective of the firm will be to close the gap between what is expected and what is received, so as to satisfy their customer and build long term relationship with them. To close this very important customer gap, four other provider gaps are needed to be closed provider gaps are the result of the following,

Gap 1

Gap 1 results because the firm fails to accurately understand exactly what the customer's expectations are. These differences arise between company or firm perceptions of customer expectation and what customers actually expect.

Gap 2

Gap 2 results when the firm's understanding of the customer does not get translated into the right design and standards of the expected service.

Gap 3

Gap 3 results when performances through systems, processes and people does not match with the design and standards of the service.

Gap 4

Gap 4 results when performance promised is not delivered to customer. The firm must ensure that what is promised to customer matches what is delivered. Thus, the service marketer must first close the customer gap between customer perception and expectation which is only possible when the four provider gaps are closed. The gaps model emphasizes on strategies and processes that firms can employ to drive service excellence. Any company interested in delivering quality service must begin with a clear understanding of its customers.

3.8 Service Culture & Innovation

Q21. Define service culture ? Explain the element of Service Culture ?

Ans :

Service Culture

'Service culture', is defined as a "a culture where an appreciation for good service exist and providing the good service to internal as well as external customers. This is considered a natural way of life" and every one is treated equally. Such kind of norms should be followed by everyone.

This definition has many implications,

1. If there is an "appreciation for good service" than only a service culture exists.
2. Good service is always given to internal as well as external customers.

   All people within the organization deserve the same service, it is not possible to promise excellent service or good service to final customers.
3. Good service is a 'Natural way of life' because it comes naturally and most important norm of the organization.

A good service culture is difficult to sustain and it cannot be developed within a day or two. It can be developed by knowing the strength of human resource and internal marketing practices. Even the companies which started with an intention of customer focus and strong service such as Disney, FedEx, Ritz-Carlton & Charles Schwab, still take constant attention in sustaining their established service culture.

Role of Culture in Services

Organizations need to establish and nurture a good service culture in their organization as there exists a direct link between good service culture and competitive advantage a firm enjoys.

In case of any service organization, the management cannot supervise its employees all the time. In such situation, the firm can rely upon the type of service culture it maintains to influence the thoughts, behaviour and attitude of its employees which intum create a positive or negative impact upon the customers.

Elements of Service Culture

The important elements of service culture are as follows,

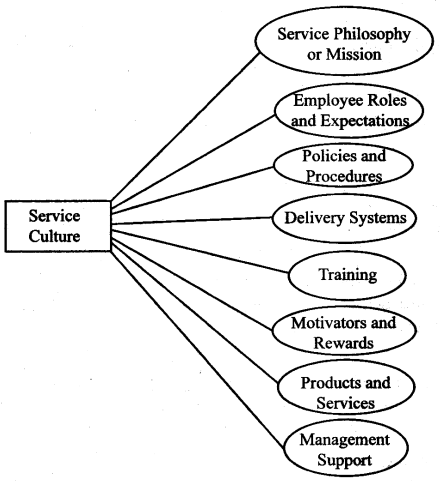


Fig.: Elements of a Service Culture

1. Service Philosophy (or) Mission

This is one of the important elements of service culture. It demonstrates the vision of direction of an organization which facilitates regular interaction with the customer.

2. Employee Roles and Expectations

It involves the communication with the employees regarding what the company expects from them in terms of performance.

3. Policies and Procedures

Policies and procedures are nothing but the guidelines which guide in managing different situations.

4. Delivery Systems

It is the way in which the organization make delivery of its products and services.

5. Training

In order to ensure excellent service delivery, the organizations give guidelines and instructions to employees using different methods which help in employee's skill and knowledge development.

6. Motivators and Rewards

The organizations provide monetary rewards, material items and appropriate feedback to employees so as to encourage them towards effective delivery of services.

7. Products and Services

It includes products, materials and services which are competitively priced and fulfills the requirements of customers.

8. Management Support

The management make sure that it answers the questions of frontline employees and assists them in making interaction with customers whenever needed.

Q22. Define Service Innovation ? Explain various types of Service innovation?

Ans :

Service Innovation

Service innovation is being defined differently by different people while few people consider it as innovation and enhancement associated with service offerings, other considers it as the new internal service processes that helps an organization to become more efficient and productive in nature. The use of new technology support systems for frontline employees depicts this kind of service innovation.

The term service innovation is also associated with the main change initiatives in an organization. For instance, when a conventional manufacturing company makes a decision to go for transformation of its overall market strategy for enhancing service and provide solution rather than focussing on the products.

Types of New Service Innovation

The different types of new service innovations are,

1. Service Offering Innovations Service offering innovations includes,

(i) Major Innovation: Major innovations are the new services which are introduced in the markets and are unknown to customers Example

Federal express, first nation wide overnight small-package delivery etc.,

(ii) Startup Business: It includes the new services which are already introduced by the existing services and fulfills the same generic need. Example

ATM, automatic coffee vending etc.

(iii) Service Line Extension

Service line extension is expanding the services of the product line.

Example

KFC extended its menu by adding new fast food items.

(iv) Service Improvements

Service improvements are the common forms of innovations which involves the changes in the features of the present service.

Example

Banking hours are extended to improve the speed of service execution.

(v) Style Changes: In this type of innovation, only the appearance is changed.

Example

Restructuring the organisational climate, repainting the tourist bus with new colour schemes, etc.,

2. Innovating Around Customer Roles

Innovation takes place not only when the service offerings are enlarged or changed, it might also take place when customer's role is redefined.

Example

Making an assumption that the customer acts as a buyer, user or payer in the service system. The new services would take place only when the customer's role is redefined.

3. Innovation through Service Solutions

Majority of the organisations have found that the customer is greatly concerned about the solutions of their problems instead of searching one stand alone product or service.

Various researchers have found different service solution as follows,

(i) Lance Bettencourt, recommends that customers must be served in a better way. They must be provided with solutions to their problem by doing so, it would result is service innovation.

(ii) While Lance Bettencourt emphasized on the customers and their requirements. The other researchers focus on customer activity chain i.e., the development of services and solutions to improve the activities.

When companies look forward to provide solutions to the customers they usually take an initiative to listen and understand problems of customers and then accordingly start developing the services with the help of innovative solutions. An example of innovative service solution is facebook. It offers online social solution to the customers.

Short Question and Answers

1. Define work study.

Ans :

Work Study, deals with the evaluation of work methods and equipments used in carrying out a job, creating an optimum work method and standardizing the desired work methods. The effective utilization of work study method, helps in attaining increased productivity. Work Study, makes use of method study and work measurement to assure that, the human and material resources which are used for performing specific activities are effectively utilized.

The main aim of work study, is to help the management to make optimum utilization of human, machine and material resources for achieving the predetermined tasks/work.

According to British standard Glossary defines work study as follows: "It is a generic term for those techniques, particularly method study and work measurement, which are used in the examination of human work in all its contents, and which lead systematically to the investigation of all the factors which affect the efficiency and economy of the situation being reviewed, in order to effect improvement.

2. Advantages of work study.

Ans :

i) Work study helps in improving the productivity and operational effectiveness.

ii) It helps in decreasing the cost of manufacturing.

iii) It helps in enhancing the work place layout.

iv) The use of work study method, helps in effective manpower planning as well as capacity planning.

v) Work study, helps in developing effective working conditions for the employees.

vi) It helps in providing improved work flow.

vii) Work study helps in decreasing the cost of material handling.

3. Define method study

Ans :

Method Study is a technique of systematic recording, observing and critically analyzing the existing ways of doing work or task with the objective of enhancing the existing method and developing new and cost effective method which reduces the costs.

Objectives of Method Study

The objectives of method study can be studied as follows,

i) To examine the present method of performing any job activity or operation.

ii) To create or design a method for enhancing the productivity and decreasing the operating cost.

iii) To decrease the material handling or material movement, as it helps in reducing the weakness or fatigue of employees.

iv) To make the optimum utilization of resources.

v) To remove the unnecessary motions.

4. Define work measurement?

Ans :

Work Measurement

Work measurement is also called time study. Work measurement is absolutely essential for both the planning and control of operations. Without measurement one cannot determine the capacity of facilities and costs.

Objectives of Work Measurement

The use of work measurement as a basis for incentives is only a small part of its total application. The objectives of work measurement are as follows:

i) Comparing alternative methods.

ii) Manpower requirement planning.

iii) Planning and control.

iv) Realistic costing.

v) Financial incentive schemes.

vi) Delivery date of goods.

5. Time Study

Ans :

Fedric W.Taylor developed the concept of Time Study. (Stop watch method in 1881). It is the most commonly used work measurement method in industry all over the world. According to this method standard time and Normal time estimates of a job are determined by making physical observations, with the help of a mechanical device like stop watch or video camera.

Time study is defined by ILO (International Labour Organisation) as "Work Measurement technique for recording the times and rates of working for the elements of a specified job carried out under specific conditions, and for analysing the data so as to obtain the time necessary for carrying out the job at a defined level of performance."

Time Study

The following equipment is required to carry out a time study analysis.

- A stop watch
- A study board
- Time study forms
- A calculator
- A reliable clock with a seconds hand e Set of measuring instruments like tape, steel rule, micrometer, spring balance, tachometer (measures rotational speed) etc.
- Cine camera equipment and accessories, with variable speed attachment.

6. Working Sampling

Ans :

It is a method of finding the percentage occurrence of a certain activity by statistical sampling and random observations.

In this method large number of random observation are made over a specified period of time on a group of workers, machines and process.

7. Predetermined Motion Time System (PMTS)

Ans :

PMTS is a work measurement technique whereby times established for basic human motions (classified according to the nature of the motion and the conditions under which it is made) are used to build up the time for a job at a defined level of performance.

a) Select large number of workers doing varieties of jobs under normal working conditions in industries.

b) Record the job operations on a movie film. (Micromotion study).

c) Analyse the film, note down the time taken to complete each element and compile the data in the form of a table or chart.

8. Define services

Ans :

Services can be defined in the following ways,

i) "Service is an identifiable, intangible activity that is the main object of a transaction designed to provide satisfaction to the customers".

ii) Services include "All economic activities whose output is not a physical product or construction, is generally consumed at the time it is produced and provides added value in forms (such as convenience, amusement, timeliness, comfort or health) that are essential concerns of its first purchaser.

iii) The American marketing association defines services as "services are the activities, benefits or satisfaction which are offered for sale and provided in connection with the sale of goods".

iv) Services are "Economic activities that produce time, place, form or psychological utilities".

v) A service is an act or performance offered by one party to another. Although the process may be tied to a physical product, the performance is intangible and does not normally result in ownership of any of the factors of productions.

9. Define service culture ?

Ans :

'Service culture', is defined as a "a culture where an appreciation for good service exist and providing the good service to internal as well as external customers. This is considered a natural way of life" and every one is treated equally. Such kind of norms should be followed by everyone.

This definition has many implications,

1. If there is an "appreciation for good service" than only a service culture exists.
2. Good service is always given to internal as well as external customers.

   All people within the organization deserve the same service, it is not possible to promise excellent service or good service to final customers.
3. Good service is a 'Natural way of life' because it comes naturally and most important norm of the organization.

10. Define Service Innovation

Ans :

Service innovation is being defined differently by different people while few people consider it as innovation and enhancement associated with service offerings, other considers it as the new internal service processes that helps an organization to become more efficient and productive in nature. The use of new technology support systems for frontline employees depicts this kind of service innovation.

The term service innovation is also associated with the main change initiatives in an organisation. For instance, when a conventional manufacturing company makes a decision to go for transformation of its overall market strategy for enhancing service and provide solution rather than focussing on the products.

Choose the Correct Answers

1. The time allotted for completing a task at standard performance is [a]

   (a) Standard time (b) Allowed time

   (c) Basic time (d) Standard rate

2. In which type of service operation, there will be high level of customer involvement? [b]

   (a) Customer-as-product service operation

   (b) Customer-as-participant service operation

   (c) Quasi-manufacturing service operation

   (d) None of the above

3. Which of the following comes under the dimensions of service quality? [c]

   (a) Reliability (b) Responsiveness

   (c) Both (a) and (b) (d) All the above

4. Services are characterized as, [d]

   (a) Intangible (b) Inconsistent

   (c) Inseparable (d) All the above

5. A service environment made up of factors like values, norms, beliefs, rituals etc., is known as [a]

   (a) Service culture (b) Service innovation

   (c) Service quality (d) Service positioning

6. PMTS stands for [c]

   (a) Predictable Motion Time System

   (b) Perfect Motion Time System

   (c) Predetermined Motion Time System

   (d) Percentage Motion Time System

7. In the process charts, which is the symbol used for 'Inspection'? [c]

   (a)  (b) 

   (c)  (d) 

8. Process charts include [d]

(a) Outline process chart (b) Operation process chart

(c) SIMO chart (d) All the above

9. Which of the following comes under external measures of service quality? [d]

(a) Number of rental terminations (b) Net gained/lost customers

(c) Number of service calls per product (d) Both (a) and (b)

10. Which of the following comes under the techniques of method study? [a]

(a) Process charts (b) Time study

(c) Work sampling (d) PMTS

Fill in the blanks

1. The two main components of work study are method study and _____.
2. Activity sampling is also known as _____.
3. _____ is defined as "the usage of techniques which are developed by the experienced and professional workers plan and create the work content of a particular task by ascertaining the time needed to perform the work as per the predetermined standards".
4. In _____ type of service operation, customers are involved to such an extent that the service is performed on the customer.
5. _____ refers to the quality of core services as well as facilitating services which assists in increasing the importance of core services to the customer.
6. _____ is the data which is collected from within the company by employees or management.
7. The two types of positioning strategies in services are _____ and _____.
8. In _____ type of service operation, production takes place as much as in manufacturing.
9. Service _____ may be defined as the new internal service processes that helps an organization to become more efficient and productive in nature.
10. _____ deals with the evaluation of work methods and equipments used in carrying out a job, creating an optimum work method and standardizing the desired work methods.

ANSWERS

1. Work measurement
2. Work sampling
3. Work measurement
4. Customer-as-product
5. Service quality
6. Internal Data
7. Service design, production process
8. Quasi-manufacturing
9. Innovation
10. Work study

UNIT IV

Materials Management

Need and importance of Materials management. Materials Requirement Planning, Manufacturing Resource Planning. Purchase Management: Sources of Supply of Materials, selection, evaluation and rating of Vendors . Methods of vendor rating. Value Analysis : the concept and its role in cost reduction.

4.1 MATERIAL MANAGEMENT

Q1. Define material management. What are the objectives of material management.

Ans : **(Dec.-19, Dec.-18, Imp.)**

The materials management involves all activities relating to materials starting right from the time the need of materials arises and ending with its issuance to production. In this way, materials management is also concerned with all the activities of management such as planning, organizing, directing, controlling and coordinating so far as they are related to the materials.

Definition of Material Management

According to one of early definitions. "Materials management is the planning, directing, controlling and coordinating of all those activities concerned with materials and inventory requirements, from the point of their inception to their introduction into the manufacturing processes. It begins with determination of materials' quality and quantity, and ends with its issuance to production in time to meet customers' demands on scheduled at the lowest cost."

According to Bailey and Farmer, "Materials management is defined as the management of the flow of materials into an organization to the point, where those materials are converted in to the firms end product(s).

According to Lee and Dobler, Material management is defined as, "a confederacy of traditional materials activities bound by a common idea - the idea of an integrated management approach to planning, acquisition, conversion, flow and distribution of production materials from the raw material state to the finished product state".

According to Ammer, Materials management is defined as, "the process by which an organization is supplied with goods and services that it needs to achieve its objectives".

Objectives of Material Management

A) Primary Objectives

1) **Low Prices:** Obtaining the least possible price for purchased materials is the most obvious purchasing objectives and certainly one of the most important. If the purchasing department reduces the prices of the items it buys, operating costs are reduced and profits are enhanced. This objective is important for all purchases of materials services, including transportation.

2) **High Inventory Turnover:** When inventories are low in relation to sales (inventory turnover sales/average inventories) less capital is tied up in inventories. This in turn increases the efficiency with which the company's capital is utilized, so that return on investment is higher. Also, storage and carrying costs of inventories are lower when turnover is high.

3) **Low Cost Acquisition and Possession:** If materials are handled and stored efficiently, their real cost is lower. Acquisition and possession costs are low when the receiving and stores-departments operate efficiently. They are also reduced the shipments are received in relatively large quantities (thereby reducing the unit cost of

handling), but they are increased if average inventories are boosted with the large shipments.

4) **Continuity of Supply:** When there are disruptions in continuity of supply excess costs are inevitable. Production costs go up, excess expediting and transportation costs are likely, and so on. Continuity of supply is particularly important for highly automated processes, where costs are rigid and must be incurred even when production stops because of material.

5) **Consistency of Quality:** Quality of end product depends on materials that go into it. When materials purchased are homogeneous and in a primitive stage (e.g. sand and gravel), quality is rarely a problem for purchasing personnel. When a variety of items of different qualities are needed and meeting rigid specifications becomes a challenge to suppliers (e.g. components of satellite), quality may become the single most important materials management objective.

B) Secondary Objectives

1) **Reciprocal Relations:** When a company deliberately buys as much as possible from its own customers, it is said to practice reciprocity. In consumer goods industries reciprocity is not a problem as the scales are spread among many users. Introducer goods industries, however reciprocity is a fact of business life. A company that is a customer inevitably wants to become a supplier. They purchasing manager must impress upon the marketing manager and everybody else that the reciprocal relationship with the customer is in the best interest of the company.

2) **New Materials and Products:** Engineering and manufacturing managers are always interested in new products and materials that will help them more efficiently and thereby achieve one of their primary objectives. The purchasing department can help because it deals regularly with the suppliers responsible for the new developments.

3) **Economic Make-or-buy :** Make-or-buy decisions are generally made by committee consisting of departmental heads. The purchasing manager should spot the need for such a decision and refer it to the communities for action.

4) **Product Improvement :** This is the most important primary objective of engineering department but purchasing department can assist the engineering department. Their economic knowledge can supplement the technical skills of the engineers on programmes to boost profits through product change. The engineering of any product is basically a compromise, between design and economic objectives. Purchasing personnel can help engineers achieve their design objectives more economically by suggesting materials or components that will do a better or equivalent job at lower cost.

Q2. Explain the scope of materials management.

Ans : **(Dec.-19)**

Materials management has a wider scope. Its scope includes the following:

(i) Materials Planning and Control

Materials planning and control is carried out, on the basis of sales forecast and production plans. It also includes, ascertaining the needs of individuals, with respect to the components, preparation of materials budget, determining the levels of inventories, scheduling the orders and inspecting and controlling the performance, with respect to production and sales.

(ii) Purchasing

The purchasing functions consist of selecting the sources of supply with respect to purchase, placing purchase orders, follow-up

maintaining a cordial relationship with suppliers, making payments to the suppliers on time, assessing and giving ratings to the suppliers, on the basis of their performance.

(iii) Stores Management

A store plays an important role in the organization tools, as its functions include physical control of materials, store preservation, preventing damages and reducing the obsolescence, by efficiently handling the materials etc. A store is also held responsible, for maintaining proper stores record, making them available whenever required, for verification of records, reconciling the records with the book figures.

(iv) Inventory Control or Management

Inventory usually refers, to the materials stock i.e, which either can be in the raw-form, semi-finished or final product for sale. Effective inventory control, helps in the smooth functioning of the production cycle, with less number of interruptions.

(v) Standardization

Standardization, refers to the process of producing diversified products, by using minimum variety of materials, parts, tools and processes. Standardization is a process where, standards or the units of measures can be compared or measured, in terms of quantity, quality, value, extent performance etc.

(vi) Simplification

Simplification is the process, which deals with minimizing different types of manufactured products. It helps in minimizing product range, assemblies, parts, materials and design.

(vii) Specifications

Specification is explained as, an accurate in-depth statement which serves the needs of the customers. It can be related to either a product process or service.

(viii) Value Analysis

Value Analysis, deals with those costs which are being added, because of inadequate and unimportant specifications and features. It makes contributions in the maturity stage of product cycle, which is the last stage. Even R&D can't make any positive contributions, with regards to the effectiveness of the products functions.

(ix) Ergonomics

It is also called as human engineering. Ergonomics, deals with man-machine system. It mainly centers around the designing of human tasks accomplishing the set-tasks controlling the human operations and complex man- machine systems.

4.1.1 Need and Importance of Materials Management

Q3. Explain the need and importance of materials management.

Ans : **(Sep.-22, Aug.-21, Nov.-20, Dec.-18, Imp.)**

Need of Materials Management

The manufacturing organizations need several infinite number of items, spare parts, components of different quality and sizes for carrying out the organizations operations effectively. In order to manage all these items, to recognize the sources of supply to make negotiations for purchasing to increase the coordination between manufacturing operations/functions and needs, engineering and drawing department, finance department and suppliers and stores, there is a need to make an individual department which takes care of all these efficiently.

As all these functions cannot be monitored by one department, therefore, there is a need for a separate division.

Organizations also maintain production management for production activity, financial management for financial aspects and so on. As half of the profits out of the total profits are generated through materials, therefore, it is effective management that leads to increase in profit margins. Thus, materials management is required for maintaining materials of the manufacturing organization and to increase the turnover, by effectively managing various operations.

Importance/Significance of Materials Management

Effective materials management helps the firm to decrease its production cost. The following points helps to know the importance of materials management,

1. Effective materials management helps in procuring materials and equipments for low prices.
2. It helps in supplying the materials continuously, for smooth flow of production process.
3. It helps in decreasing the transportation cost and reduces the lead time.
4. Materials management helps in eliminating buck passing and minimizing the materials obsolescence.
5. It helps in building an effective relationship with the supplier and maintaining better records and information.
6. It provides the scope for personal development and improves the inter departmental cooperation.

4.2 Material Requirement Planning (MRP)

Q4. What is material requirement planning (MRP) ? Explain the objective of MRP ?

Ans : **(Feb.-21, Dec.-19, Dec.-18, Jan.-18, Imp.)**

A system of planning and scheduling the time-phased material requirements for production operations. The master production schedule specifies the quantity required for each end item in each planning period, it is set of time phased requirements for end items. But the firm also needs a set of time phased requirements for item parts and raw materials that make up those end items.

Material requirements planning is a production planning and control technique in which the master production schedule is used to create production; and purchase orders for dependent demand items.

Definition of MRP

- It is a simple system of calculating arithmetically the requirement of the input materials at different points of time, based on the plan or schedule of production of the finished good.
- MRP is a computer-based information system for scheduling production and purchases of dependent demand items. It uses information about end product demand, product structure and component requirements, production and purchase lead times and current inventory levels to develop cost-effective production and purchasing schedules.
- MRP is a system of planning and scheduling the item Phased materials requirement for production operations.

Objectives of MRP

1. Inventory Reduction

MRP determines how many units of a component are needed and when they are needed to meet the master schedule. Therefore it enables the mangers to procure that component as it is needed, thereby reducing the costs of excessive inventory.

2. Reduction in Production and Delivery Lead Times

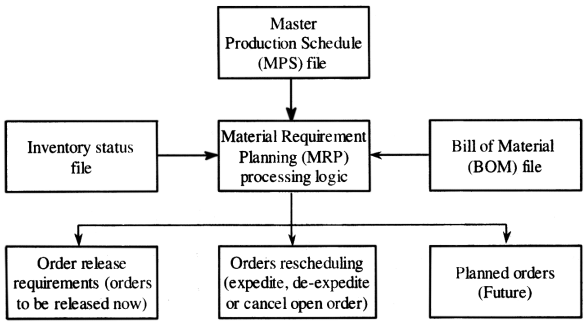
MRP identifies materials and components quantities, timing, availabilities, production & procurement actions required to meet delivery deadlines.

By coordinating inventories, procurement and production decisions, MRP helps in avoiding delays in production. It priorities production activities by putting due dates on customer job orders.

3. Realistic Commitments

By using MRP, production can give marketing timely information about likely delivery times to prospective customers.

The figure given below outlines the main components of Material Requirement Planning (MRP) system:



In the above figure, we can see that the Master Production Schedule File, Inventory Status File and Bill of Material File, are the three major inputs of MRP. System and order release requirements, order rescheduling and planned orders release, are the output of MRP system.

(a) Master Production Schedule (MPS)

- The MPS is developed from firm's customer orders or from forecasts of demand before the MPS system begins to operate.
- The MPS is designed to meet market demand. So, it identifies the quantity of each end product and when it is to be produced during each future period in the production planning horizon.
- Service components for customers are also entered as end items in the MPS.
- The MPS provides the focal information for the MRP system.
- The MPS govern the MRP system's recommended actions on the timing of procuring materials and producing subcomponents.

(b) Bill of Materials (BOM)

This is a document describing the details of an item's product building up, including all component items, their build up sequence, the quantity needed for each of the work centers that perform the build up sequence

The BOM identifies how each end product is manufactured, specifying all subcomponent items, their sequence, their quantity in each finished unit.

This information is obtained from product design documents, work-flow analysis and other standard manufacturing and industrial engineering documentation.

(c) Inventory Status File

It consists the complete documentation of the inventory status of each item in the product structure, on-hand quantity, safety stock level, quantity allocated and led-time. The MRP system must retain the up to date file of the inventory status of each item in the product structure.

This file provides accurate information about of every item controlled by the MRP system, which can then maintain an accounting of all inventory transactions, both actual and planned.

(d) The MRP Processing Logic

The MRP processing logic accepts the Master schedule and determines the components schedules for successively lower level items of the product structures.

It calculates for each item in each product structure and for each time period in the planning horizon, how many of that item are needed i.e. gross requirement, how many units from the inventory are already available i.e. available quantity, the net quantity that must be planned on receiving in the new shipments (planned order receipts), and when orders for the new shipments must be placed so that all materials arrive just when needed.

This data processing continues until it has determined the requirements for all the items used to meet the MPS.

Q5. What are the advantages and disadvantages of material requirement planning?

Ans : **(Feb.-21, Dec.-19, Dec.-18, Imp.)**

Advantages of MRP

1. Requires less inventory levels
2. Involves low idle time
3. Needs less setup time
4. Capable of altering the MPS
5. Holds the capability to price more competitively
6. Good customer service
7. Provides good response to market demands
8. Less sales price

9. Helps in the capacity planning
10. Helps managers to use the planned schedule
11. Helps in deciding as to when to expedite or deexpedite
12. Provides an information about delays or cancelled orders.

Disadvantages of MRP

1. Top management do not show proper concern for MRP i.e., as they are not committed.
2. MRP constitutes only a part of total system, but it has been regarded as a complete and stand along system to enable the working of a firm.
3. The functioning of MRP with just-in-time production system, has become an issue.
4. MRP requires a greater accuracy to operate/ function.
5. MRP is too rigid in nature, as it creates a schedule and in case of emergencies it is difficult to divert from the schedule.

4.3 MANUFACTURING RESOURCES PLANNING

Q6. Write about manufacturing resources planning.

Ans : **(June-18)**

Manufacturing Resource Planning (MRP II)

A method for the effective planning of all resources of a manufacturing company. Ideally, it addresses operational planning in units, financial planning in dollars, and has a simulation capability to answer what-if questions. It is made up of a variety of processes, each linked together: business planning, production planning (sales and operations planning), master production scheduling, material requirements planning, capacity requirements planning, and the execution support systems for capacity and material. Output from these systems is integrated with financial reports such as the business plan, purchase commitment report, shipping budget, and inventory projections in dollars. Manufacturing resource planning is a direct outgrowth and extension of closed-loop MRP.

Closed-loop MRP

A system built around material requirements planning that includes the additional planning processes of production planning (sales and operations planning), master production scheduling, and capacity requirements planning. Once this planning phase is complete and the plans have been accepted as realistic and attainable, the execution processes come into play. These processes include the manufacturing control processes of input-output (capacity) measurement, detailed scheduling and dispatching, as well as anticipated delay reports from both the plant and suppliers, supplier scheduling, and so on. The term closed loop implies not only that each of these processes is included in the overall system, but also that feedback is provided by the execution processes so that the planning can be kept valid at all times.

The MRP systems were developed on a segregated basis. MRP is an integrated information system that shares data among and synchronizes the activities of production and other functional areas of the business.

The MRPII is a step ahead of the first generation MRP. It synchronizes all aspects of the business. The MRPII system coordinates sales, purchasing, manufacturing, finance and engineering by adopting a focal production plan and by using one unified database to plan and update the activities in all the system.

The rationale for having these functional areas work together is the increased likelihood of these developing a plan that works.

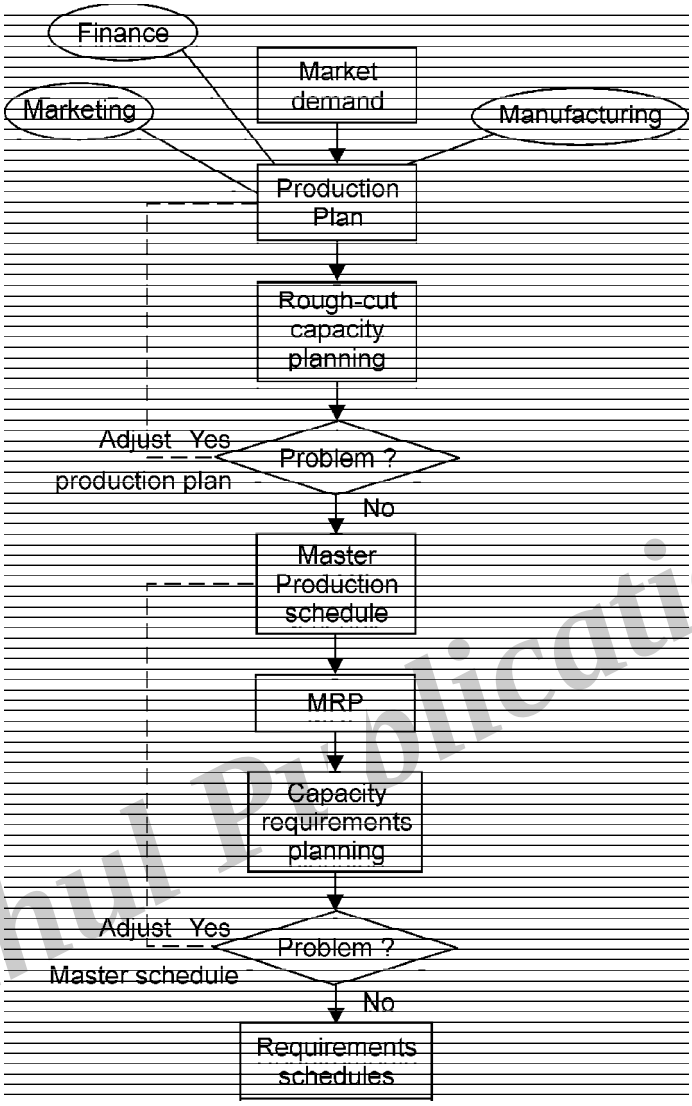


Fig.: MRP Process

Moreover, because each of these functional areas has been involved in formulating the plan, they will have good knowledge of the plan and reason to work towards achieving it.

An initial plan must be revised often, based on the assessment of availability of various resources. Once these have been decided, the master production schedule can be firmed up. At this point, material requirement planning comes into play, generating material and schedule requirements.

Next, the management must make detailed capacity requirement planning to determine whether these specific capacity requirements can be met. Adjustments in the master production schedule can be done if required.

When the actual work begins, a variety of reports help the managers to monitor the process and to make any necessary adjustments to keep the operations on track. This is a continuing process, where the MPS is updated and revised necessary to achieve corporate goals.

4.3.1 Differences Between MRP-I and MRP-II

Q7. Distinguish between MRP-I and MRP-II.

Ans :

The various difference between MRP-I, MRP-II are as follows.

MRP-I	MRP-II
1. MRP-I or MRP is a computerized information system of planning and sequencing the time-phased requirements of raw materials for the different operations involved in production or manufacturing of a product.	1. MRP-II is an extension of MRP-I wherein it focuses upon other key areas of business besides the production! department.
2. It mainly focuses on raw materials including, CRP (Capacity Resource Planning) with respect to time.	2. MRP-II not only takes into consideration the basic MRP-system i.e., production, planning and control activities but also considers the information related to other departments such as, finance, HR, engineering marketing division and accounts.
3. It is simple and easy in nature but doesn't provide any useful and integrated information.	3. It has been developed to fill in the loopholes of MRP-I: It provides the useful and integrated information by taking into consideration the different aspects of business in a broader sense.
4. It was represented and followed as a complete single system to run a concern instead of being a part and parcel of the whole system.	4. It has been developed, to overcome the problems of MRP-I and its functions as a part and parcel of the total system.
5. It is implemented by only a few manufacturing organisations.	5. It is being implemented by many of the manufacturing concerns and it is considered important in providing or managing information system at different levels.
6. MRP-1 is the part and parcel of MRP-II.	6. MRP-II is broader in concept.
7. It focuses or highlights only on three fundamental requirements. They are, inventory levels control, preference to operating level, capacity to load production system.	7. It coordinates and combines sales, purchases, manufacturing, finance, accounts, engineering by implementing well designed and well defined production plans and makes use of a single database to plan and alters the changes in the activities of the system.
8. It is concerned with production planning only.	8. It is concerned with both production planning, as well as financial planning in a systematic manner.
9. MRP-I though one of the best techniques for managing inventory, lacks behind as it does not take into consideration the other resources of an organisation.	9. MRP-II takes into consideration all the resources of the organisation.
10. It focuses only upon one department i.e., production and planning department and thus does not make quick and prompt decisions.	10. It focuses upon all the departments of the firm which enable it to make prompt and joint decisions.

4.4 Purchase Management

Q8. What is purchase management ? Explain different types of purchase systems.

Ans : **(Aug.-19, Imp.)**

Purchase Management

Purchasing management refers to the effective management of raw materials/inputs purchased for manufacture infinished goods. Purchasing management basically aims at purchasing appropriate raw materials and other items and reducing costs to the maximum extent. Specific features of purchasing management includes,

- Ensuring continuous supply of raw materials/ inputs.
- Purchasing appropriate inputs at right time, right price and in right quantity and quality.
- Analyzing suppliers market and selecting best suitable vendor.

Classification of Purchase Systems

The purchase system may be classified into Pre-Purchase System, Ordering System and Post-Purchase System.

1. Pre-purchase System

This includes making requisitions, requirement programmes, selection of suppliers, obtain quotations and evaluating them.

2. Ordering System

Once the decision on supplier and the rates are finalized, the order is placed with the selected supplier. The next task is to place order. The details of order form are listed as.

- Purchase order reference number.
- Description of the materials and detailed specifications.
- Quantity required and delivery schedule.
- Price and discounts.
- Shipping instructions.
- Location where the materials are to be shipped.
- Signature of the materials manager.
- Detailed terms of conditions.

3. Post Purchase System

The activities which are included under this system are follow-up procedure, receipt and checking invoices.

Whenever an order is placed, it should be continuously monitored. The whole system operates under probabilistic environment. Though orders are placed based on demand and lead time, these are subjected to variation. As a result, some of the orders are to be expedited to avoid stockout condition. Once the items on orders are received, then they are to be checked for quantity, quality, specification, etc. The invoices are also to be checked for correct tally with the purchase order details and the details of the items supplied.

Q9. Discuss about special purchase Systems.

Ans :

The following are some special purchase systems.

1. Forward buying
2. Tender buying
3. Blanket order
4. Zero stock
5. Rate contract

1. Forward Buying

In Forward buying, the purchasing decision for a period (say 1 year) will be taken in advance and the organization will commit accordingly in terms of order quantity, rate and delivery schedule, by taking into consideration the availability of funds and the requirements. Generally, this is used for public buying to avoid favouritism to a specific vendor.

2. Tender Buying

In Tender buying the steps are: preparing bidder's list, advertising tenders, receiving bids, evaluating bids and placing order with the bidder with the lowest cost.

3. Blanket Order

In Blanket ordering system, the organization will enter into an agreement with its supplies to receive items for a required quantity at a particular rate over a period of time.

4. Zero Stock

Zero stock purchase system is in-line with using the just-in-time manufacturing system. The main idea of this system is to operate the plant with near zero inventory. If the suppliers are situated nearer to the company, they are more reliable in terms of making supply in time. The company can place orders with such suppliers. The company will generally provide even technical know-how, quality control support, etc. to its suppliers.

5. Rate Contract

Rate contract is very much used in public sectors and government departments. The suppliers are on 'rate contract' with DGS&D for a specific period. The organizations can place orders straightaway with such firms without going through the lengthy procedure of purchasing.

Q10. What are the various aspects of purchase management.

Ans : **(Aug.-19)**

The different aspects of purchasing management are as follows:

1. Price forecasting
2. Purchasing of capital equipments
3. International purchasing
4. Public buying

1. Price Forecasting

Forecasting is nothing but prediction of a future event. In Materials Management, predicting the prices of materials is of utmost importance. The precise prediction of prices would help us in buying the materials in right time and of right quantity. Especially, while dealing with agro based materials, the impact of seasonal variation on the purchase price may be incorporated while estimating the price of such materials.

The different methods which are used for price forecasting are as follows:

- Charting method
- Moving Average method
- Regression method
- Exponential smoothing method

2. Purchasing of Capital Equipments

All machineries and equipments which are used in value addition process are termed as capital equipments. The frequency of purchase of these equipment is very less, may be once in five years or ten years. But, these equipments involve huge capital outlay which is treated under fixed overhead. Hence, a careful analysis should be done before buying these items.

While comparing different alternatives, one can use any one of the following approaches to select the best alternative:

- Payback period method
- Rate of return method
- Present worth method
- Annual equivalent method
- Future worth method

The various options to satisfy the demand for capital equipment are listed below:

- purchase of new equipment
- purchase of used equipment
- leasing

For the purchase of new equipments, any one of the methods which are mentioned above may be used to judge each alternative. Then the best alternative is to be selected.

Instead, if we purchase used equipment, the market value of the used equipment should be treated as the price of the equipment while comparing alternatives.

But the organization may have limitation on fund or it may have very short lead time to procure the equipment or it may want the equipment for a short duration or such equipment will be available only on lease.

Under such cases, one has to lease the required capital equipment.

3. International Purchasing

In view of the growing global economy, many countries are importing major raw materials, sub assemblies which are available elsewhere at a cheaper rate at the same time the total cost of procurement is cheaper when compared to indigenous production/supply of the same. But in some cases, the raw materials should be imported just to have a minimum specified quality standard, or, if the raw materials are produced using hi-tech process which is not available within the country.

4. Public Buying

Many organizations are duplicating the same task of purchasing even though the specifications of the materials are the same. Whenever, an order is to be placed, there is a minimum lead time involved to get the items in addition to the minimum time required to source a supplier. These will certainly introduce delay in the purchase of materials and also adds a significant cost to the total cost of purchasing.

4.5 Sources of Supply of Materials

Q11. What are the various sources of supply of materials?

Ans :

All individuals and agencies that provide organizations with resources they need to produce goods and services are called suppliers. Suppliers have a major impact on a production system's product quality cost and distribution. Issues such as how many suppliers offer specified resources for sale, relative quality of material offered by different suppliers, reliability of supplier deliveries and credit terms provided by suppliers are all important to managing an organization in a rational effectively and efficiently.

The essence of purchasing process lies in a rational selection of the sources from which supplies of materials are obtained. The primary responsibility of purchasing department is to find out suitable sources of supply and ensure that the right quality of material is obtained in right quantities at the right time, at the right place and at the right price. It is one of the functions of the purchasing department to spend time and effort in thoroughly evaluating prospective suppliers and continuously appraising the performance of the current suppliers.

Effective investigation and evaluation combined with sound negotiation can avoid many problems in regard to supplies of materials. Finally, a supplier who is continuously improving his own product and trying to reduce his cost could be source of considerable benefit to the purchaser.

Sources of Information on Supplier

The most important sources from which information on suppliers of different types of materials is available are :

1. Trade Directories

There are several trade directories available, both national and foreign. Some deal with manufacturers and suppliers of all kind of material while some are specialized like exclusive chemical or engineering goods manufacturing.

Information on addresses, regional offices, types and range of products and addresses of agents and dealers will be posted in these directories. On line trade directories are also fast growing. There are international agencies who have word wide suppliers listed in their computer storage systems which, one can have access to from any part of the world. In India also such computer based trade directories are being developed quite rapidly.

2. Trade Journals

Many leading companies advertise in trade journals and this forms important source of information about suppliers. A purchasing department benefits considerably if it contributes to journals, which contain information relevant to their businesses. Such relevant information can be classified, indexed updated and maintained in proper files.

3. Telephone Directories

Most telephone directories contain considerable number of advertisements alphabetically arranged item wise or group wise like air conditions, castings, paperboard, etc. This is a valuable source of information on suppliers. Most of the advertisers in telephone directory are local companies.

4. Supplier's Catalogues

Many manufacturers produce catalogues or pamphlets giving details of the products they manufacturers. These catalogues can be easily obtained on request. These catalogues contain technical information, specifications, performance characteristics, price, etc. Filing of such catalogues will be useful for future references.

5. Trade Exhibitions and Fairs

Exhibitions and fairs are useful for obtaining information on new suppliers, new products or modifications of old products. Visiting exhibitions of specialist products like textile machinery, motors, office equipment, electronic equipment, etc., provides an excellent means of expanding a buyer's knowledge of new products and new suppliers.

6. Salesmen

Sometimes firms send their sales people for giving information related to their businesses to the perspective purchasers. Because of their specialized knowledge, salesmen can suggest new applications for their products, which in some cases may eliminate the search for new vendors. An alert buyer can tap their information by a right approach. Salesmen should be treated with utmost courtesy and given enough opportunity to make their sales presentations.

7. Company Personnel

Employees of other departments like engineering, sales, design, R&D, etc., within the company are another source of information on suppliers. Through their personal and professional associations these people learn about new suppliers. The purchasing department can best tap this source by maintaining cordial relationship with other departments.

8. Other Companies

Mutual exchange of information with purchase departments of other companies can be extremely beneficial not only for information about suppliers but also for evaluation and price comparison.

9. Public Tenders

This is one of the most common source of securing supplier information. The buyer states the product he wants and gives specifications or terms of purchase. Potential suppliers send their quotations.

4.5.1 Selection of Suppliers

Q12. What are the factors and issues in selection of suppliers?

Ans :

Selection of Sources

While selecting a source a firm must consider several factors.

Some of the factors which must be considered for selecting a source are as follows:

1. Lead time and On-Time Delivery

A firm must determine the lead times, that the supplier provides. They need to verify the procedures, which a supplier follows for ensuring timely deliveries and for documenting and correcting delivery problems.

2. Quality Assurance

The Quality provided by a supplier, must be examined by a finn. The procedures followed by the supplier for controlling and assuming the quality must be evaluated by the firm. It must analyze, whether the supplied takes corrective actions for quality document and conducts 'investigations for ascertaining and correcting the cause of non conforming materials.

3. Flexibility

The firm must evaluate the Flexibility of a supplier in handling the changes in, quantity, delivery schedules and product or service changes.

4. Location

A firm mostly prefers a supplier who is located near its own location as it consumes less time. So, a firm determines whether a supplier is located near to the firm or not.

5. Price

A firm must determine, whether the supplier is setting reasonable prices if he is providing the entire package and does he want to negotiate the prices.

6. Product or Service Changes

A firm considers the suppliers, who are financially stable and provides a notification, when they make any alternations in products or services.

7. Other Factors

The firms must ascertain, whether the supply depends on other buyers or not, as it leads to a risk of giving more preference to the needs of other buyers over the needs of the firm.

Issues in Selection of Suppliers

The following are the issues to be resolved while selecting the suppliers.

1. One or More Suppliers

Purchasing entire lot from one supplier earns quantity discounts for the firm; but makes it dependent on solely one supplier. There is the risk of putting all the eggs in one basket. The advantage of having multiple suppliers is that failure on part of one supplier can be adjusted by purchasing more from other suppliers. One source means consistency in quality. Two sources mean competition in improving quality. The buying organization must evaluate all these considering the criticality of the product and its availability.

2. Agent or Manufacturer

Should the buyer purchase directly from the manufacturer or his agent or stockist or through wholesaler? Though it may like as if purchasing directly from the manufacturer is cheaper, it might be really not so when one considers the overall gains through service facilities. Stockists are available locally and have direct interest in their customers and related services.

The amount of resources spent in purchasing from the stockiest in terms of paper work, follow-up, etc., is much less than in purchasing directly from the manufacturer. Again, the decision will depend upon the nature of the product in question.

3. Local or Distant Supplier

Where everything is almost equal, local supplier is always the best. Distant suppliers increase costs on transport, packaging, insurance, sales tax, otroi, etc., and there is also the difficulty of follow-up. Local source suits best to meet urgent purchase requirements and where local relationships matter for resolving disputes.

Efficiencies of distant and local suppliers should be thoroughly analyses before making final choice.

4. Reciprocity

Many organizations have a mutual arrangement with their suppliers whereby they purchase goods for the same consideration. This is called reciprocity. But such arrangements should be made considering absolute advantages and without adversely affecting any purchase requirements.

5. Small or Big

Another matter of concern is to choose a large or a small supplier. Each of large scale, medium scale and small-scale suppliers have their own special characteristics.

A large-scale manufacturer has a large clientele and good sales and after sales organization. A small-scale manufacturer can render personal attention to the buyers. Government gives excise duty and tax duty and tax concessions on products manufactured by small-scale units thereby giving a cost advantage to the buyer.

Supplier should be selected considering the circumstances prevailing in the buying organization and the advantage it is looking for.

Decision regarding the source of purchase should depend on full evaluation of all the factors pertaining to the case. Purchase manager should gather all the required facts and fully analyze these facts.

Q13. What are the different steps involved in selection of a sources.

Ans :

The important steps involved in source selection are as follows,

1. Searching
2. Selection
3. Negotiation and trial orders
4. Rating.

Step-1: Searching

In this step, various sources of supply of materials are searched.

Step-2: Selection

While selecting a source a firm must consider several factors. Some of the factors which must be considered for selecting a source are as follows,

(i) Lead Time And On-Time Delivery

A firm must determine the lead times that the supplier provides. They need to verify the procedures, which a supplier follows for ensuring timely deliveries and for documenting and correcting delivery problems.

(ii) Quality Assurance

The Quality provided by a supplier must be examined by a firm. The procedures followed by the supplier for controlling and assuming the quality must be evaluated by the firm. It must analyze whether the supplied takes corrective actions for quality document and conducts investigations for ascertaining and correcting the cause of non conforming materials.

(iii) Flexibility

The firm must evaluate the Flexibility of a supplier in handling the changes inequality, delivery schedule and product or service changes.

(iv) Location

A firm mostly prefers a supplier who is located it contains less time. So a firm determines. Whether a supplier is located near to the firm or not.

(v) Price

A firm must determine, whether the supplier is setting reasonable prices or not. A firm needs to analyst whether supplier is providing the entire package or he want to negotiate the prices.

(vi) Product or Service Changes

A firm considers those suppliers who are financially stable and provides a notification when they make any alternations in products or services.

(vii) Other Factors

The firms must ascertain, whether the supply depends on other buyers or not, as it leads to a risk of giving more preference to the needs of other buyers over the needs of the firm.

Step-3: Negotiation and Trial Orders

The firms give trial orders to the suppliers for analyzing their technical capabilities. Negotiation is a part of a buyer's day to day operations. A Purchasing Executive must determine whether the negotiation is done for cost, quality or for quantity. One must have the complete .cost data and technical data of their own company as well as their supplier companies. A Purchasing Executive needs to have information about the changing economic, technological and other trends in its own region or in the country. This information helps the buyer in supporting his statements or demands and makes them understand the difficulties and problems faced by the suppliers. Several effective buyers who conduct purchasing research have the ability to recommend methods for decreasing costs and improving quality, delivery or performance to their supplier company.

Step-4: Rating

Vendor Rating is a continuous management process used for the assessment of vendors. It is engaged in measuring, evaluating and improving the supplied performance, which drives the firms for making future sourcing decisions.

4.6 Evaluation of Suppliers/Vender

Q14. Explain briefly about evaluation of suppliers.

Ans :

Generally, the firms compare the suppliers, by considering only the quoted price and neglect the fact that, suppliers also differ on certain important aspects, which influence the total cost of using a supplier.

The following factors should be considered, while evaluating the suppliers performance apart from the quoted price.

1. Replenishment lead time
2. On-time performance
3. Supply flexibility
4. Delivery frequency/minimum lot size
5. Supply quality
6. Inbound transportation cost
7. Pricing terms
8. Information coordination capability
9. Design collaboration capability
10. Exchange rates, taxes and duties
11. Supplier viability.

All these factors must be considered while rating the supplier's performance as all these factors influences the supply chain cost.

1. Replenishment Lead Time

Evaluating the supplier's performance with regard to replenishment lead time helps the firm to determine how each supplier affects the cost of holding a safety inventory. When the replenishment lead time from a supplier increases, the buyer needs to increase his safety inventory levels, as it grows proportional to the square root of replenishment lead time.

2. On-time Performance

The on-time performance, influences the variability of the lead time. A reliable supplier has a low variability and an unreliable vendor has a high variability. With an increase in the lead time variability, the needed safety inventory at the firm increases proportionally.

3. Supply Flexibility

It is the extent of variation in order quantity which a supplier allows without allowing other performance factors to depreciate. If the supplier is less flexible, then the lead time variability will be more and is shown as order quantities change. Hence, the level of safety inventory which a firm has to carry, is influenced by supply flexibility.

4. Delivery Frequency/Minimum Lot Size

The size of each replenishment lot ordered by a firm is influenced, by the delivery frequency and the minimum lot size provided by the supplier. With an increase in the replenishment lot size, the cycle inventory at the firm also increases, resulting in an increase in the cost of holding inventory.

The required safety inventory is influenced by delivery frequency in a firm using a periodic review policy.

5. Supply Quality

The lead time and lead time variability of the suppliers are influenced by the supply quality, as the follow up orders must be fulfilled, for replacing the defective products. Due to this, the firm has to hold more safety inventory from a low quality supplier, when compared to high quality supplier. After the relationship between the supply quality, lead time and lead time variability is determined, the suppliers quality level can be transformed into

the required safety inventory and related holding cost. The quality also influences the customer satisfaction, due to rework, lost material and inspection cost.

6. Inbound Transportation Cost

The suppliers cost not only depends on the distance, type of transportation, delivery frequency but also on the inbound transportation cost.

4.7 VENDOR RATING

Q15. Define vendor rating? What are the factors determining vendor rating?

Ans : **(Aug.-21, Aug.-19, Imp.)**

Along with prior evaluation of vendors before purchase, it is important to appraise their performance periodically. This performance appraisal, which is, and should be done as a continuous monitoring exercise is termed as "Vendor Rating".

Determinants of Vendor Rating

The following are the factors determining the vendor rating.

1. Price

Price is one of the most important consideration while making any type of purchases. Price is the major factor, which is observed keenly by any firm before making purchases.

2. Quick Delivery

Normally, companies prefer only those vendors (suppliers) who provide quick delivery or, on time delivery of products. Supplying firms can provide this facility to the companies by maintaining the stock in the form of warehousing.

3. Inventory Plans

Suppliers should make plans for storing the stock as this enables them to accept the proposals and deliver the products at right time. Effective planning of inventory and its storage by suppliers usually increases demand for their products and enables efficient delivery system.

4. Market Information

Suppliers should keep the track of current market information with respect to customer expectations, taste and preferences, customers buying behavior etc., as this helps them to produce the products preferred by the customers. A purchasing company also keeps record of present market situation and prefers only those suppliers/vendors who produce the products as per the demand. Market information is one of the major factor determining the vendor.

5. Service

Different services are offered by different suppliers. Suppliers usually provide services like, machinery repairs when breakdown or failure occurs, replacement of item when it is found defective/damaged, gives instructions for how to operate machinery or equipment etc. The Purchasing Company while rating the vendors, considers the above aspects and rates them as per their needs/requirements.

6. Co-Operation

Cooperation acts as key aspect to enhance the productivity as well as profitability. Suppliers should cooperate with the purchasing firms during sales as it helps in building strong relationship between them.

7. Financial Position

Suppliers should maintain their financial status, as it indicates suppliers capabilities with regard to producing a product, offering quality product, prompt delivery, etc. The purchasing company prefers only those suppliers who offer products with good quality and quick delivery.

8. Freight and Delivery Charges

Suppliers should give certain discounts to the purchasing companies, at the time of sales. For instance, less freight charges, no installation cost on machinery/equipment, less charges for delivery, etc. Purchasing firms consider these costs at the time of vendor rating.

9. Credit Facilities

Suppliers should provide credit facilities to the purchasing companies such as, allowing partial payment at the time of purchases and the rest of the payment at the time of delivery or within the specified time limit. Purchasing companies consider credits facilities provided by suppliers, while rating the vendors.

4.7.1 Methods of Vendor Rating the Supplier

Q16. What are the various methods of vendor rating?

Ans : **(Sep.-22, Aug.-21, Aug.-19, June-18, Imp.)**

Vendor rating methods are designed to assist the purchasing department to select a new vendor or to appraise the performance of current/vendors.

These methods formalize ranking process by making objective evaluation through some quantitative data obtained from the vendors or from past experience of the purchasing department. Three of such methods are :

1. Categorical Plan Method

- Buying team members consisting of personnel form various divisions such as purchasing, engineering, quality control, inspection and receiving prepare a list of performance factors that are important for them.
- Each major supplier is evaluated against each of these factors.
- At periodic intervals, say monthly or quarterly, a performance report is prepared giving an overall group evaluation in simple categorical terms such as preferred, neutral or unsatisfactory.

Merits

- Simple and easy to operate
- Buyers observe the performance of vendors since they have to discuss the same with the vendors.

Demerits

- The method is subjective in nature. Each person's criteria for evaluation may be different.
- If the buying team members do not maintain routine records group evaluation may not be accurate.

2. Weighted Point Method

This is the most widely used method vendor rating. The following are the steps involved in this method.

- **Assigning weightages :** All the factors that are important to the firm are assigned percentage weightages according to their relative importance. Usually quality, delivery and price are the three factors considered as important.
- **Express quantitative terms for measuring performance:** For example, quality may be evaluated basing on the number of rejections due to poor quality.
- Delivery may be evaluated basing on the number of lots received in time.
- *Sum up* the rating points for all the factors to obtain composite rating that will serve as the base for choosing a new vendor or continuing with the old one.
- **Give the final rating :** Vendors may be assigned ranks I, II, III, etc., based on their rating results and one with the top rank may be chosen. Or the firm may determine a cut off point of say 80% or 90%, below which it may not choose any vendor at all even if it gets the top rank.

3. Cost Ratio Method

This method involves an intricate system of determining the actual costs incurred on purchasing. Costs such as follow-up, transportation, packaging, duties, receiving, etc., will increase or decrease the total cost depending on whether they are borne by the buyer or the vendor.

- Obtain the unit cost of the material supplied
- Determine unit costs involved in purchasing that are to be borne by the buying organization. Few of such costs are:
  - Transportation
  - Packaging
  - Receiving
  - Quality costs
  - Delivery costs
  - Inspection costs
  - Loss due to rejections
  - Reworking costs
  - Follow-up costs
- Express each of the above costs as a percentage of total purchase value. For example, if the delivery costs amount to Rs. 2000 for a total purchases of Rs.200000 then

$$\text{Delivery cost ratio} = \frac{2000}{200000} \times 100$$
$$= 1\%$$

- Adjust unit cost for the cost ratios

For instance if the unit cost is Rs.2 and Delivery cost ratio as calculated above is 1%. Assuming inspection costs to be 2%

Total unit cost = Rs.2 + 1% + 2%
= Rs.2.003

The higher the cost the lower is the supplier's comparative rating.

4. Checklist System

Some companies use a simple checklist to evaluate their vendors. A typical checklist is given below.

Buyer's checklist for evaluating vendors.

i) Reliability: Is supplier a reputable, stable, financially strong company

a) Are the supplier's ability and integrity proved by pass performance ?

b) Is supplier giving me savings along with product improvements ?

ii) Technical Capabilities

a) Will supplier provide engineering assistance?

b) Will supplier provide design assistance?

c) Can supplier handle special needs and designs?

d) Does supplier contribute to general advancement through basic research ?

iii) After sale service

a) Does supplier have a service shop organization available when and where I may need it ?

b) Is emergency service available ?

c) Will renewal parts be available when I need them?

iv) Availability

a) Will supplier assure on-time delivery ?

b) Are stocks available locally? On short notices?

c) Is supplier's location an advantage to me?

d) Does supplier plan shipment to minimize my inventory ?

e) Can supplier be depended upon to provide a steady flow of products or materials?

v) Buying convenience

a) Does supplier offer full line of related products ?

b) Does supplier package his product conveniently for my use ?

c) Does supplier have a local sales contract? Is he qualified to help me ?

vi) Sales assistance

a) Does supplier help develop mutual markets? Will he recommend our products?

b) Will the appearance of supplier's product enhance the appearance of my product?

4.7.2 Role of Vendors in Operation Management

Q17. What is the role of vendors in operation Management?

Ans :

Vendors a play a very important role in the production and operations management. Any delay in delivering the materials or defects in the item supplied, significantly affects the production schedule, increases the inventory costs and results in delays in delivering the end products.

Role of Vendors in Productions and Operations Management

The role of vendors in productions and operations management can be studied as follows:

1. On-time Delivery

The vendors, by providing the materials on-time to the company, contribute towards the smooth flow of production process. Any late deliveries can disrupt the production process. Hence, vendors, ensure on-time delivery of material to the organization.

2. Quality

By supplying the right quality of material to the organization, vendors, contribute towards the production of high quality products and reduces the wastage.

3. Low Inventory Cost

By making the on-time delivery, the vendors reduce the inventory cost which in turn improves the productivity.

4. Reasonable Price

The reasonable price quoted by the vendors, enables the company to make the bulk purchases from them. Some vendors also offer discounts on bulk purchases, which helps in reducing the purchasing cost.

5. Inventory Policy of Vendor

The vendors, by maintaining an inventory policy for keeping the spare parts in advance helps the firms in times of an emergency equipment break down. In such cases, the companies can take the help from vendors, to avoid the delays in the production process.

6. Improves Customer Satisfaction

The good quality material and on-time delivery provided by the vendors, help in developing quality products for the customers. This in turn improves the customer satisfaction,

4.8 VALUE ANALYSIS - CONCEPT

Q18. Define value analysis? What are the objectives of value analysis?

Ans : **(Feb.-21, Nov.-20, Imp.)**

Value analysis is a cost reduction and control technique which operates by attacking the basic design of the product. Value is a broad term often used to denote cost/price. Value analysis is in the engineering context, sometimes is called as Value Engineering.

Need and Development of Value

In the present imperfect world most managers find themselves Value Analysis can provide a disciplined way of attacking cost. Inherent desire in the man to make cheaper and to sell cheaper at the same time keeping the utility or function of the product some lead to the development of Value Analysis.

Origin of Value

Developed in 1947 in U.S.A. by L.D. Miles and Value analysis has no place where all the designs were as economical, simple and elegant as possible.

To producer, the value can be defined as

$$\text{Value} = \frac{\text{Work}}{\text{Cost}} = \frac{(\text{Use} + \text{Esteem})}{\text{Cost}}$$

to customer, the value can be

$$\text{Value} = \frac{\text{Work}}{\text{Price}} = \frac{(\text{Use} + \text{Esteem})}{\text{Price}}$$

Types of Values

There are different out looks for value. They are

i) **Cost Value :** Cost of Manufacturing of a Product.

ii) **Use Value :** Functional Value considers the work done, functions performed or services rendered by a product.

iii) **Esteem Value :** Involves the qualities and appearance – desire to possess the product.

iv) **Exchange Value :** Exchange with some other product.

v) **Price :** Cost plus/Penetrating price.

vi) **Worth :** Utility of the product/service and its properties features of attractiveness that induces us to own the product.

Essence of Value Analysis

The essence of value analysis is to identify the functions and to examine the alternative ways in which this function can be achieved and finally to choose the one with least cost.

Functions of Value

The function value is the property which makes the product work or sell.

Identification of the Function

Most valuable but most difficult part is to make a formal statement of the function of a product. But broadly one can see the following three functions.

i) **Primary function :** It is a function of a product which is basic to the product.

Example: Lamp – gives light

Teal Beam – Supports weight

Shaft paint to ship – act against corrosion and deterioration.

ii) **Secondary Function :** In addition to the primary function, the product should have a secondary function.

Example: Recognize from the colour and identify the organization.

iii) **Tertiary function :** The third function can add value to the two functions mentioned above.

Example : Brilliant appearance. Improved Elegance.

Objectives of Value Analysis

1. Objective of best buy

In purchase of material, components, one should look for

$$\text{Value} = \frac{\text{Worth}}{\text{Price}} = 1$$

2. Objective of saving in cost

In producing (or) manufacturing or transporting or storing or in any other operation, Value analysis searches for saving in cost by concentration on functional utility of the item.

Identification of unnecessary costs with a view to effect cost reduction.

Unnecessary cost can be due to

a) Lack of technical information about latest technological development

b) Lack of cost information of alternative methods.

c) Lack of ideas or lack of time, results in picking up new designs/products or similar other factors.

$$\text{Value} = \frac{\text{Work}}{\text{Cost}}$$

3. The objective of enhancing the worth

Improvement of quality, elegance of the product during designing stage. It includes packaging stage as well.

Q19. Outline the process of value analysis process.

Ans :

Value analysis is a cost reduction technique which aims at developing the ideas that reduces the cost of the product or increases the product utility.

The steps involved in value analysis process are shown in the figure given below,

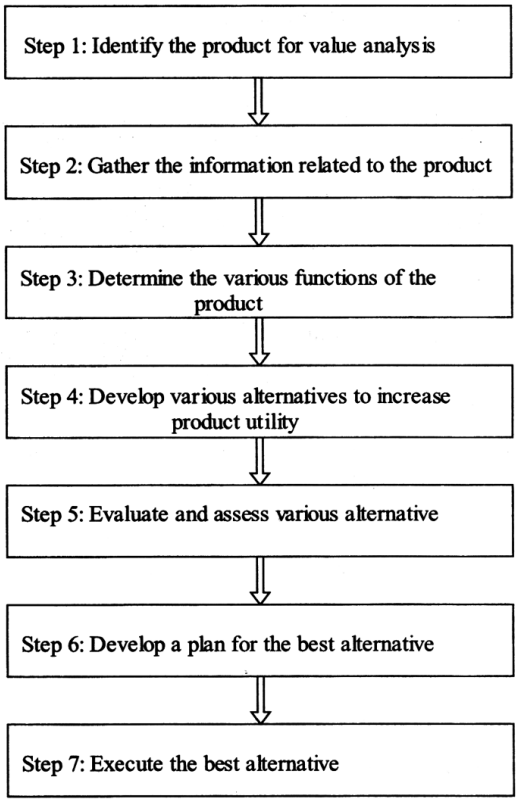


Fig.: Value Analysis Process

Step 1: Identify the Product for Value Analysis

The value analysis process begins with identifying the product for which value analysis has to be conducted. The product identified for value analysis must increase the sales revenue after it is redesigned and must not become outdated in future. Value analysis can be conducted either for the entire product or few elements of the product.

Step 2: Gather the Information Related to the Product

The next step is to gather significant information about the product. This information is related with the,

(a) Manufacturing processes, layout of machine and instruction sheets

(b) Total cost information and marketing information

(c) Technical specifications with the help of diagram

(d) Plant capacity and time consumption details

(e) Recent developments in the product substitutes.

Step 3: Determine the Various Functions of the Product

In this step, the various functions to be performed by the product such as, primary functions, secondary functions and tertiary functions are determined and defined. The functions involving high cost are also identified in this step.

Step 4: Develop Various Alternatives to Increase Product Utility

After gathering significant product information and determining the functions of each element of the product, the next step is to develop various alternatives for increasing the product utility. The team performing value analysis can conduct brainstorming sessions for gathering ideas from different people and motivating them to share their valuable opinions and suggestions.

Step 5: Evaluation of Alternatives

The various alternatives recorded in the step 4 are evaluated and assessed for determining the extent to which each alternative can meet the financial and technical requirements of the firm. After evaluating all the alternatives the alternatives which are technically effective and involves less cost are selected for further examination.

Step 6: Develop a Plan for the Best Alternative

In this step, a comprehensive plan is developed for the selected ideas while examining them. Development plans involves preparing diagrammatic representations, developing models and conducting meetings with concerned departments.

Step 7: Execute the Best Alternative

Finally, the best alternative or idea is transformed into a prototype and used in manufacturing activities. The performance and outcomes of this prototype is recorded. Functional analysis and product cost analysis are conducted for determining the net savings derived from value analysis.

The tools of value analysis are given below.

1) Design Analysis
2) Cost Analysis

1. Design Analysis

a) Can any part be eliminated without affecting the overall functions?

b) Can the design of the part be simplified to reduce the cost?

c) Can the design of the part be changed to permit the use of simplified and less costly production methods ?

d) A less expensive but equally satisfactory material be used in the part ?

Four specific techniques are used in

(i) The Value Analysis checklist.

(ii) The functions & cost approach.

(iii) The use of brain storming.

(iv) The use of suppliers in the program.

2. Cost Analysis

Investigation of suppliers probable costs of producing a given product and estimates the costs of material, labour, manufacturing overhead and general overhead. Obtain total cost and add profit margin.

4.8.1 Cost Reduction Techniques

Q20. Explain about cost reduction techniques.

Ans : **(Nov.-20, Imp.)**

The following are being used as the different techniques of cost reduction,

1. Activity Based Management (ABM)

Activity based management refers to the use of Activity Based Costing (ABC) in order to enhance the operations and also to identify and abolish the non-value added cost and activities.

2. Value Chain

The value chain analysis is a set of inter connected value creating activities. These activities includes the component suppliers, basic raw materials, ultimate end-use product or services to be provided to the customer. Value chain analysis helps in achieving greater customer satisfaction and manages costs very effectively.

3. Kaizen Costing

"Kaizen" is a Japanese word. The kaizen costing represents continuous and slow enhancement of a process with the help of small activities rather than the large or radical enhancement or through innovation or large investment technology. This technique of cost reduction is usually being followed during the manufacturing phase of an existing product.

4. Management Audit

Management audits are also called as performance audits and these audits helps the management in performing their job in a better way by recognizing waste, inefficiency and suggesting a corrective action.

Management audits are being used as a technique of cost reduction by both profit and non-profit organizations.

5. Just-In-Time (JIT) System

This technique primarily aims at manufacturing the needed qualitative items, in required quantity and at the required time. JIT is applicable for the items with high inventory carrying costs which intum is associated with holding high inventory levels.

6. Business Process Re-engineering

Re-engineering refers to a complete redesigning of an existing process with an intention to identify the new, simple, innovative way to attain the desired objective. Business process reengineering basically emphasizes on quality enhancement, simplification, cost reduction, increased customer satisfaction, etc., there by enhancing the key business process of an organisation.

7. Life Cycle Costing

Life cycle costing is a type of cost reduction technique which involves predicting and collecting costs over a products entire life cycle. This activity helps in ascertaining whether the profits earned during the manufacturing phase would include costs incurred during the pre and post manufacturing stage.

8. Bench Marking

It is a process in which one organization compares its performance with the other outstanding organization who, performs better than them. This helps the organization, in identifying and learning the techniques adopted by the outstanding organisation to achieve its goals and have high level performance.

9. Target Costing

Target costing is a technique of designing a product and processes in such a way that the product manufactured helps the firm in earning the profit when it is being sold at an estimated market driven price. This estimated price is know as target price.

10. Total Quality Management (TQM)

Total Quality Management (TQM) is a technique which helps the organisation to manage and improve all its business function so that it can provide qualitative products and services to the customers and full fill their requirements.

4.8.2 Role of Value Analysis in Cost Reduction

Q21. Explain the role of value analysis in cost reduction.

Ans : **(Feb.-21, Jan.-18, Imp.)**

After the products are developed they passes through the value engineering or value analysis process. This analysis helps in determining whether any product or material can be substituted or redesigned to perform the same process at a lower cost.

After the original products are modified, designed and produced, these products are further examined and tested to determine the extent to which the quality, performance and costs matches with the design objectives.

The role of value analysis in cost reduction can be understood from the following points,

1. Value analysis helps in decreasing the cost of the existing products or systems.
2. It helps in avoiding the unwanted cost in the new products or systems.
3. The use of value analysis results in overall cost consciousness and develops a general attitude towards costs.
4. It encourages import substitution.
5. It helps in enhancing the value of the product by using new materials and processes.
6. It is a faster cost reduction technique.
7. It helps the firms to save costs and attain higher profits.
8. As value analysis team can be formed from the staff who are available in different sections or departments. Therefore, it needs very less expenditure.
9. Value analysis improves the utility of the product by simplifying it, by using better material and by using efficient and easier manufacturing methods.
10. It helps in recognizing the useless functions and tries to eliminate them.
11. It helps in avoiding duplication and additional costs by integrating common functions in between different elements into fewer ones.
12. It helps in determining the components and materials which can replace the costly items.

Short Question and Answers

1. Define Material Management

Ans :

The materials management involves all activities relating to materials starting right from the time the need of materials arises and ending with its issuance to production. In this way, materials management is also concerned with all the activities of management such as planning, organizing, directing, controlling and coordinating so far as they are related to the materials.

Definition of Material Management

According to one of early definitions, "Materials management is the planning, directing, controlling and coordinating of all those activities concerned with materials and inventory requirements, from the point of their inception to their introduction into the manufacturing processes. It begins with determination of materials' quality and quantity, and ends with its issuance to production in time to meet customers' demands on scheduled at the lowest cost."

According to Bailey and Farmer, "Materials management is defined as the management of the flow of materials into an organisation to the point, where those materials are converted in to the firms end product(s).

According to Lee and Dobler, Material management is defined as, "a confederacy of traditional materials activities bound by a common idea - the idea of an integrated management approach to planning, acquisition, conversion, flow and distribution of production materials from the raw material state to the finished product state".

According to Ammer, Materials management is defined as, "the process by which an organisation is supplied with goods and services that it needs to achieve its objectives".

2. Significance of Materials Management

Ans :

Effective materials management helps the firm to decrease its production cost. The following points helps to know the importance of materials management,

i) Effective materials management helps in procuring materials and equipments for low prices.

ii) It helps in supplying the materials continuously, for smooth flow of production process.

iii) It helps in decreasing the transportation cost and reduces the lead time.

iv) Materials management helps in eliminating buck passing and minimizing the materials absolesence.

v) It helps in building an effective relationship with the supplier and maintaining better records and information.

vi) It provides the scope for personal development and improves the inter departmental cooperation.

3. Material Requirement Planning

Ans :

A system of planning and scheduling the time-phased material requirements for production operations. The master production schedule specifies the quantity required for each end item in each planning period, it is set of time phased requirements for end items. But the firm also needs a set of time phased requirements for item parts and raw materials that make up those end items.

Material requirements planning is a production planning and control technique in which the master production schedule is used to create production; and purchase orders for dependent demand items.

Definition of MRP

- It is a simple system of calculating arithmetically the requirement of the input materials at different points of time, based on the plan or schedule of production of the finished good.

- MRP is a computer-based information system for scheduling production and purchases of dependent demand items. It uses information about end product demand, product structure and component requirements, production and purchase lead times and current inventory levels to develop cost-effective production and purchasing schedules.
- MRP is a system of planning and scheduling the item Phased materials requirement for production operations.

4. Disadvantages of MRP

Ans :

i) Top management do not show proper concern for MRP i.e., as they are not committed.

ii) MRP constitutes only a part of total system, but it has been regarded as a complete and stand along system to enable the working of a firm.

iii) The functioning of MRP with just-in-time production system, has become an issue.

iv) MRP requires a greater accuracy to operate/ function.

v) MRP is too rigid in nature, as it creates a schedule and in case of emergencies it is difficult to divert from the schedule.

5. Purchase management.

Ans :

Purchasing management refers to the effective management of raw materials/inputs purchased for manufacture infinished goods. Purchasing management basically aims at purchasing appropriate raw materials and other items and reducing costs to the maximum extent. Specific features of purchasing management includes,

- Ensuring continuous supply of raw materials/ inputs.
- Purchasing appropriate inputs at right time, right price and in right quantity and quality.
- Analyzing suppliers market and selecting best suitable vendor.

6. Post Purchase System

Ans :

The activities which are included under this system are follow-up procedure, receipt and checking invoices.

Whenever an order is placed, it should be continuously monitored. The whole system operates under probabilistic environment. Though orders are placed based on demand and lead time, these are subjected to variation. As a result, some of the orders are to be expedited to avoid stockout condition. Once the items on orders are received, then they are to be checked for quantity, quality, specification, etc. The invoices are also to be checked for correct tally with the purchase order details and the details of the items supplied.

7. Categorical Plan Method

Ans :

- Buying team members consisting of personnel form various divisions such as purchasing, engineering, quality control, inspection and receiving prepare a list of performance factors that are important for them.
- Each major supplier is evaluated against each of these factors.
- At periodic intervals, say monthly or quarterly, a performance report is prepared giving an overall group evaluation in simple categorical terms such as preferred, neutral or unsatis-factory.

Merits

- Simple and easy to operate
- Buyers observe the performance of vendors since they have to discuss the same with the vendors.

Demerits

- The method is subjective in nature. Each person's criteria for evaluation may be different.
- If the buying team members do not maintain routine records group evaluation may not be accurate.

8. Define value analysis? What are the objectives of value analysis?

Ans :

Value analysis is a cost reduction and control technique which operates by attacking the basic design of the product. Value is a broad term often used to denote cost/price. Value analysis is in the engineering context, sometimes is called as Value Engineering.

Need and Development of Value

In the present imperfect world most managers find themselves Value Analysis can provide a disciplined way of attacking cost. Inherent desire in the man to make cheaper and to sell cheaper at the same time keeping the utility or function of the product some lead to the development of Value Analysis.

9. Kaizen Costing

Ans :

"Kaizen" is a Japanese word. The kaizen costing represents continuous and slow enhancement of a process with the help of small activities rather than the large or radical enhancement or through innovation or large investment technology. This technique of cost reduction is usually being followed during the manufacturing phase of an existing product.

10. Just-In-Time (JIT) System

Ans :

This technique primarily aims at manufac-turing the needed qualitative items, in required quantity and at the required time. JIT is applicable for the items with high inventory carrying costs which intum is associated with holding high inventory levels.

Choose the Correct Answer

1. The _____ specifies the quantity required for each end item in each planning period. [a]
   (a) MPS (b) MRP-I
   (c) MRP-II (d) MPR
2. The purpose of MRP includes, [d]
   (a) Helps in forecasting future requirements
   (b) Order planning and control
   (c) To determine capacity requirements of both plants and equipments
   (d) All of the above
3. _____ is the standard tool of the JIT System. [b]
   (a) Push system (b) Pull system
   (c) IT system (d) Production system
4. _____ method involves quantitative techniques for evaluation. [a]
   (a) Weighted point plan (b) Cost-ratio method
   (c) Critical incidents method (d) The categorical plan
5. Cost control is a _____ action. [b]
   (a) Corrective action (b) Preventive action
   (c) Measurable action (d) All the above
6. _____ is defined as the time which is required to move orders in the production process from receipt to delivery. [c]
   (a) Variability (b) Throughput
   (c) Lead time (d) Waste management
7. In source selection N.T.O stands for, [b]
   (a) No trial orders (b) Negotiations and trial orders
   (c) Negotiations and trade orders (d) None of the above
8. The major role of vendors include the following, [b]
   (a) Maintaining input and output
   (b) Improving productivity and production plan
   (c) Improving profit margins
   (d) Increasing inventory cost
9. Which of the following analysis is used for cost reduction? [a]
   (a) Value analysis (b) Vendor analysis
   (c) EOQ Analysis (d) Performance analysis
10. One of the stages of source selection is, [d]
    (a) Deciding (b) Product assortment
    (c) Vendor management (d) Rating

Fill in the Blanks

1. _____ acts as a means for quality assurance and acceptance sampling.
2. _____ acts as a link between a firm's intermediate term and short-term production planning and scheduling functions.
3. The buyers can judge vendor's performance by evaluating _____.
4. Learning curve is also called _____.
5. _____ deals with managing the flow of materials in an organization to that point where those materials are being converted into the firm's end product(s).
6. Use value is also called as _____.
7. _____ method computes the actual costs involved in the process of procurement, purchasing, transportation, receiving materials etc.
8. MRP maintains effective coordination between _____ and _____.
9. Material requisition is also known as _____.
10. _____ is the real and permanent reduction in the unit cost of goods manufactured or services rendered without impairing their quality and suitability for the intended use.

ANSWERS

1. Vendor rating system.
2. MRP
3. Delivered goods quality, time of delivery and price standard
4. Improvement curve
5. Materials management
6. Function value
7. Cost-ratio
8. Purchase orders and jobs
9. Stores requisition
10. Cost reduction

UNIT V

Stores Management:

Inventory decision: Need ,functions and Significance of Inventory, Safety Stock. Deterministic Models of Inventory: Purchase and Manufacturing Models without and with shortages. Probabilistic Models of Inventory : Fixed order quantity systems and fixed period quantity systems

Stores Management: Functions of Stores and Materials control. Classification, Codification , Simplification and Standardization of materials . Bin Card, Double-Bin and stores Ledger. Selective Inventory Control: ABC, XYZ, VED, FNS and SDE Analysis.

5.1 Inventory Decision

Q1. Define the term inventory.

Ans :

Inventory is simply a stock of physical assets having economic value, which can be either in the form of material, money or labour. Inventory is also known as an idle resource as long as it is not utilized. Inventory may be regarded as those goods which are procured, stored and used for day to day functioning of the organization. This can be in the form of physical resource such as raw materials, semi-finished goods used in the production process, finished products ready for delivery to consumers; human resources such as unutilized labour, or financial resource such as working capital etc.

The decisions which are directly related with the management of firm's inventory (stock) are referred as inventory decisions. These decisions helps the firm to maintain efficient balance between three types of costs such as.

a) Inventory shortage costs

b) Inventory holding costs

c) Inventory ordering costs.

5.1.1 Need of Inventory

Q2. Explain the need of inventory?

Ans :

Every firm should maintain sufficient stock of inventories for the following reasons

1. The materials are not immediately available whenever an order is placed for fresh stock. The period between the time of placing the order and time of arrival of stock is subjected to variations. A firm should hence hold some reserve stock in order to allow production operations to continue even if delay occurs in procurement.
2. Due to the variation in the demand, changes may occur in the manufacturing program. In order to meet the increased demand, the company must have enough inventory/stock to allow the production without interference.
3. Stock-out occurs, when a firm has little inventory and runs out of stock. The stock-out of essential materials means interruption in the production. Due to the interruption in the production the cost of production.
4. Stock-out means interruption in production, which there by delay the delivery of goods to the customer. After few such delays even a patient customer would start looking out for another supplier who can give him better service.
5. The men and machinery will remain idle, if there is a stock-out of materials. Hence, for better utilization of men and machinery, the company must keep enough stock of inventories.
6. Some times, due to wide fluctuations in the output and in the demand of certain materials, the materials become scare. To ensure that production operations are unaffected by the scarcity of materials, a reserve stock must be maintained by the firms.

5.1.2 Functions of Inventory

Q3. What are the various functions of inventory?

Ans : **(Sep.-22)**

The basic function of inventory is to increase profitability through manufacturing and marketing support. Since zero inventory manufacturing-distribution system is not practical, it is important to remember that each rupee invested in inventory should be committed to achieve a specific objective. Other basic functions of inventory are geographical specialization, decoupling, balancing supply and demand, and safety stock.

1. Inventory Investment Alternative

Inventory is a major area of asset deployment which should be required to provide a minimum return 011 investment. The marginal efficiency of capital (MEG) concept holds that a firm should invest in those alternatives that provide a greater return than capital cost to borrow. Figure shows that investment alternative A 011 the MEG curve is acceptable.

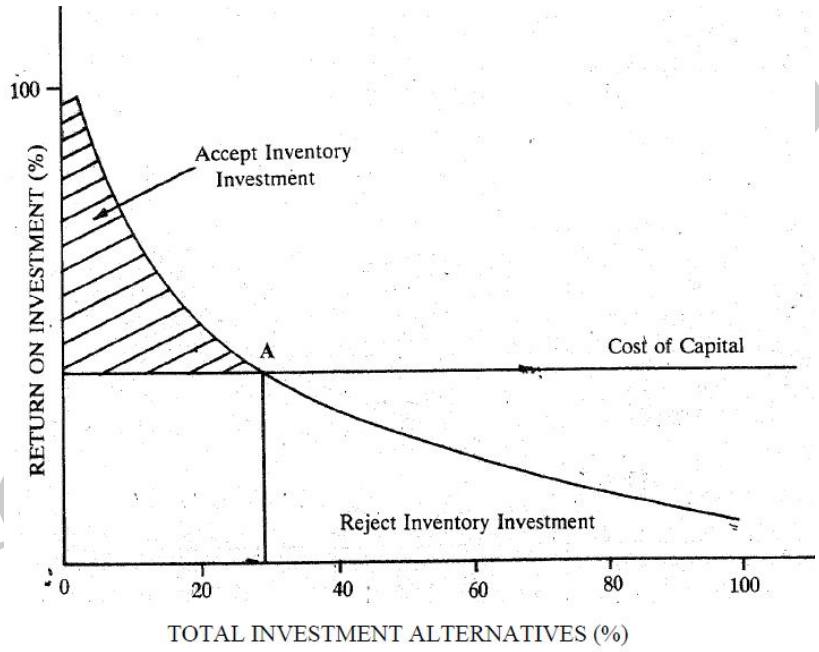


Fig. : Typical Marginal Efficiency of Capital Curve (MEC)

The MEC curve shows that about 20 per cent of the inventory investment alternatives will give a return on investment above the cost of capital. Every organization is interested in return-on-investment or return on assets employed. Return on assets is profits divided by assets. In other words;

Return on Capital (Assets) = Profits/Capital (Assets)

$$\left(\frac{\text{Profits}}{\text{Sales}}\right)\left(\frac{\text{Sales}}{\text{Capital}}\right) = \left(\frac{\text{Profits}}{\text{Sales}}\right)\left(\frac{\text{Sales}}{\text{Assets}}\right)$$

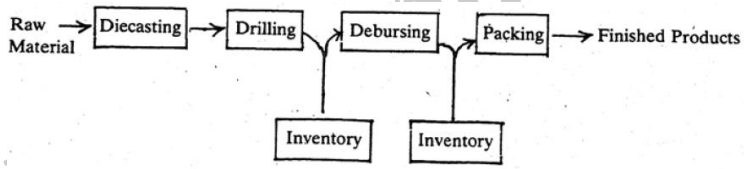
Profits over sales is the profit margin. It depends upon many factors including uncertainties of change. Sales over capital is capital turnover. One way to improve return-on-investment is to increase turnover or keep the assets in inventory low.

2. Geographical Specialization

Another function of inventory is to allow geographical specialization of individual operating units. Due to factors of production such as power, raw materials, water and labour the economical location for manufacturing is often a considerable distance from areas of demand. The manufactured goods from various locations are collected at a simple warehouse/plant to assemble in final product or to offer customers a single mixed product shipment. This also provides economic specialization between manufacturing and distribution units of an enterprise.

3. Decoupling

Tins function of inventory is to provide maximum efficiency of operations within a single facility. Decoupling is done by breaking operations apart so that one operation's supply is independent of anther's supply. This decoupling function serves two purposes. First, inventories are needed to reduce the dependencies among successive stages of operations so that break-downs, material shortages, or other production fluctuations at one stage do not cause later stages to shut down. Figure illustrates this concept in an engineering firm. Since debarring packing could continue to operate from inventories should diecasting and drilling be shut down or they can be decoupled from the production processes that precede them. A second purpose of decoupling is to let one organization unit schedule its operations independently of another. For example, in an automobile organization, engine built up can be scheduled separately from seat assembly, and each can be decoupled from final automobile assembly operations through in process inventories.



4. Balancing Supply and Demand

Balancing function concerns elapsed time between consumption and manufacturing. Balancing inventories exist to reconcile supply with demand. The most notable examples of balancing are seasonal production and year round consumption like sugar. Another example of year round production and seasonal consumption is woolen textiles. Inventories in a balancing capacity link the economies of manufacturing with variations of consumption. The balancing function of inventory requires investment in seasonal stocks which are expected to be frilly liquidated, within the season.

5. Safety Stock

The safety stock or buffer stock function concerns short range variation in either demand or replacement. A great deal of inventory planning is devoted to determining the size of safety stocks. Safety stock provides protection against two types of uncertainty. The first type of uncertainty is concerned with sales in excess of forecast during the replenishment period. The second type of uncertainty concern delays in replenishment.

The inventories committed to safety stocks represent the greatest potential for improved performance. A variety of techniques are available to develop safety stocks which can be adjusted rapidly in the event of error or a change in policy.

5.1.3 Significance of Inventory

Q4. Explain the significance of maintaining inventory.

Ans : **(Sep.-22, Imp.)**

Inventory refers to the stock of the products that a firm is offering for sale to produce final products. In other words, inventory is composed of assets that can be sold by the firm in the future causes of business operations.

Thus, inventory represents the least liquid current asset of a firm, which constitutes an important component of firm's balance sheet. Inventory could be in the form of raw materials, WIP and finished goods that have been stored in warehouses.

Significance of Inventory

Different logisticians have suggested different reasons for maintaining inventory in logistics. Some major reasons can be dealt here as follows,

1. Improves Customer Service

It has improved its customer service by providing marketing assistance through which products can be made available to the customers whenever they need them.

2. Economics of Scale X

It is seen both in production and transportation functions. In case of manufacturing firm, it can be achieved by producing large number of units such that the total cost can be spread over large number of units. Similarly, a transportation firm can achieve it by carrying large number of products.

3. Hedging Against Uncertainties

It helps in overcoming the problems related to uncertainties. Such uncertainties may be due to demand fluctuations and also due to variations in suppliers replenishment lead times. Such uncertainties can be tackled/ managed efficiently by investing in safety stocks ensuring the achievements of acceptable service levels.

4. Hedging Against Contingencies

Inventory management enables the firms to continue their production process even in case of natural calamities such as cyclones, fires, floods and other problems creating variables.

5. Lot Size

It usually refers to the practice of purchasing products in bulk volume which exceeds the demand/ consumption rates so as to obtain economies of scale either by offering trade discounts or by causing bulk products per trip of transportation.

6. Specialization

Through the management of stocks, firms could be able to achieve specialization in their manufacturing activities. After processing of raw materials, they can be transported to different distribution centres. Firms undertake such processes to achieve economies of scale in manufacturing and transportation systems.

7. Inventory as a Buffer

As the channel members are distantly located, "buffer stock" has to be kept at various critical interfaces which can be used for safeguarding various processes such as procurement, manufacturing, distribution etc. Thus, the wide-acceptance philosophy of SCM has a profound impact on the flow of inventories throughout the manufacturing and logistics systems.

5.2 Safety Stock / Buffer Stock

Q5. Define safety stock. What are the various methods used in computation of safety stock?

Ans :

The safety stock is defined as the minimum additional inventory to serve as a safety margin or cushion to meet an unanticipated increase in usage resulting from various uncontrollable factors.

In real life situations, firms operate under conditions of uncertainty relative both the demand as well as procurement time. Total actual demand may be more or less than the forecasted demand. Similarly, actual procurement time may vary from the estimated time. In order to minimize effect of uncertainty in demand and/or lead time a firm maintains safety stock.

Thus, safety stock is held for the following reasons,

(a) Any excessive in-process rejection

(b) Rejections at the time of receipts

(c) Unexpected delay in delivery of goods

(d) Fluctuations in demand.

The concept of safety stock can be clearly understood with the help of graphical presentation.

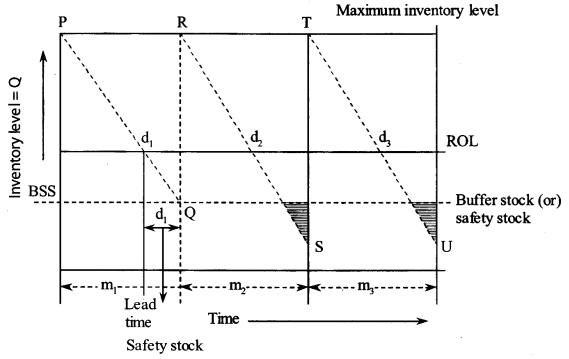


Fig.: Safety Stock

During Time Period (m_1)

The delivery time (d_1) and rate of demand (P-Q) will be the same as expected. At this stage, there is no shortage of inventory. Thus, safety stock is not needed.

During Time Period (m_2)

Rate of demand is high (i.e., RS when compared to PQ). Shortage of inventory arises due to longer period of lead time (d_2). Thus, safety stock is needed.

During Time Period (m_3)

In this time period also, the rate of demand is high, (i.e., TU = RS). Shortage of inventory arises due to longer lead time (d_3). So, for overcoming shortages, safety stock is needed.

By assuming lead time (d) and consumption rate (c) as constant, Reorder level can be expressed as,

$$ROL = d \times c$$

Methods for Computation of Safety Stock

The different methods are used for computing the safety stock which are as follows,

(a) NPC Method

Safety stock = [Maximum lead time - Normal lead time] x Monthly consumption

$$SS = [d_{max} - d] \times c$$

(b) Statistical

By assuming Poisson's or normal distribution, the mean values of lead time (d) and consumption (demand) rate (c) namely are computed as y_1 and y_2. The standard deviation of d, c and (d × c) namely R_1, R_2, and R_3 respectively are also calculated. Then safety stock is expressed as,

$$SS = K.R_3$$

Where,

$$R_3^2 = 3(R_1 \times R_2)^3 + (y_1 \times R_2)^2 + (y_2 \times R_2)^2$$

K values from assurance level is subjected to normal distribution as,

Assurance level in %	50	68	96	100
K-values	0	1	2	3

(c) Graphical

A graph differentiating stock out % from stock/ demands per month is shown below,

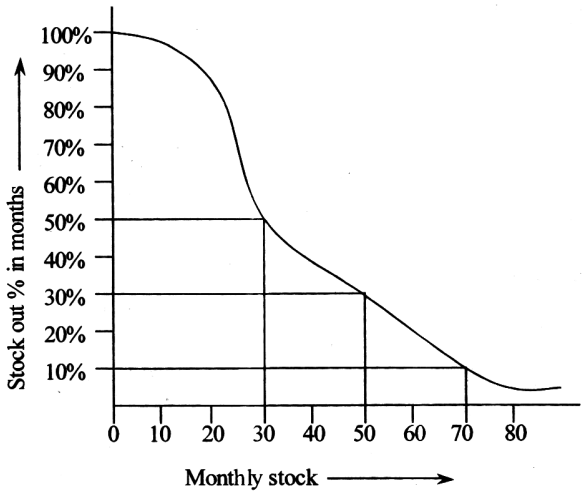


Fig. : Monthly Stock

At 10% stock out,

Stock needed = 70 unit

Average demand = 30

Assume lead time as one month

∴ Safety stock = 70 - 30 × 1 = > 40 units

At 30% stock out

SS = 50 - 30 x 1 = > 20 units

At 50% stock out

SS = 30 - 30 × 1 ⇒ 0

Hence, average demand is 30 and stock required is also 30 units.

(d) Percentage of Average Demand

The percentage of average demand helps in providing the most accurate estimate.

The safety stock should be set between 25% to 50% of average demand for a specified lead time requirement.

Example

Average demand = 500 units

Lead time = 2 months

Stock required = 30%

SS = 500 × 2 × ⇒ 300 units.

(e) Square Root Lead Time

$SS = D\sqrt{d}$

Where,

D = Average demand

d = Lead time

Example

d = 4 months and average demand

= 500 units

Safety stock = 500 $\sqrt{4}$ ⇒ 1000 units.

(f) Conservative Estimate

Safety Stock = [Maximum usage - Average usage] [Longest lead time]

SS = [Maximum consumption - Average consumption] [Longest lead time]

$SS = [c_{max} - c]d_{max}$

Total Cost

Safety stock increases the total stock which is expressed as,

$$T = \left[\frac{D}{Q}\right]_{C_0} + \left[S + \frac{Q}{2}\right]_{C_h}$$

T = Safety stock

D = annual demand in units

C_n = Ordering cost

C_h = Inventory carrying cost per unit per year.

Substituted as,

$$Q = EOQ = \sqrt{\frac{2DC_0}{C_h}}$$

$$T = DC_0\sqrt{\frac{C_h}{2DC_o}} + \left[S + \sqrt{\frac{2DC_0}{C_h}} \times \frac{1}{2}\right]C_h$$

$$= \sqrt{\frac{DC_0C_h}{2}} + \sqrt{\frac{2DC_0C_h}{2}} + SC_h$$

$$\therefore \quad EOQ = \sqrt{2DC_0C_h} + SC_h$$

5.3 Deterministic Models of Inventory

Q6. Discuss about various deterministic models of inventory.

Ans : **(Aug.-21)**

Models of Inventory

There are different models of inventory. The inventory models can be classified into deterministic models and probabilistic models. The various deterministic models are is given below

1. Purchase model with instantaneous replenishment and without shortages.
2. Manufacturing model without shortages.
3. Purchase model with instantaneous replenishment and with shortages.
4. Manufacturing model with shortages.

These models are explained in the following sections.

5.3.1 Purchase Model with instantaneous Replenishment and without Shortages

Q7. Explain about Purchase Model with instantaneous replenishment and without shortages.

Ans : **(Aug.-21, Nov.-20, Imp.)**

In this model of inventory, orders of equal size are placed at periodical intervals. The items against an order are replenished instantaneously and the items are consumed at a constant rate. The purchase price per unit is the same irrespective of order size. Let,

D be the annual demand in units.

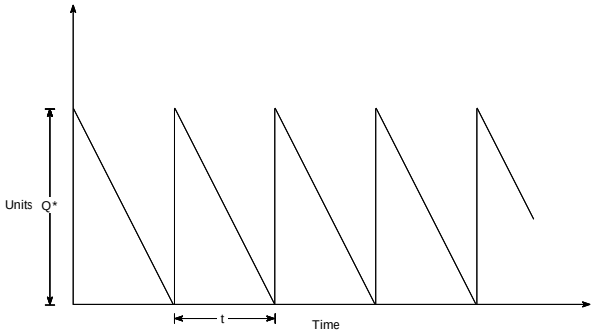
C_o be the ordering cost/order

C_c be the carrying cost/unit/year

P be the purchase price per unit

Q be the order size

Then, the corresponding model is shown in figure.



Therefore,

The number of orders/year = $\frac{D}{Q}$

Average inventory = $\frac{Q}{2}$

Cost of ordering/year = $\frac{D}{Q} \times C_o$

Cost of carrying/year = $\frac{Q}{2} \times C_c$

Purchase cost/year = D × P

The total inventory cost (TC)/year

$$= \frac{D}{Q} \times C_o + \frac{Q}{2} \times C_c + D \times P$$

Differentiating w.r.t Q yields

$$\frac{d}{dQ}(TC) = \frac{-D}{Q^2} C_o + \frac{C_c}{2}$$

The second derivative = $\frac{+2D}{Q^2} C_o$

Since the second derivative is positive, we equate the first derivative to zero to get the optimal value for Q.

$$\frac{-2D}{Q^2} C_o + \frac{C_c}{2} = 0$$

$$Q^2 = \frac{2C_oD}{C_o}$$

$$Q^* = \sqrt{\frac{2C_oD}{C_o}}$$

No. of orders = $\frac{D}{Q^*}$

Time between orders = $\frac{Q^*}{D}$

Example

Alpha industry estimates that it will sell 12,000 units of its product for the forthcoming year. The ordering cost is ` 100 per order and the carrying cost per unit per year is 20 per cent of the purchase price per unit. The purchase price per unit is ` 50.

Find

a) Economic order quality (EOQ)

b) No. of orders per year

c) Time between successive orders.

Sol.:

a) D = 12,000 units/year

C_o = ` 100/order

C_c = ` 50 × 0.2

= 10/unit/year

Therefore

$$EOQ = \sqrt{\frac{2C_oD}{C_o}}$$

$$= \sqrt{\frac{2\times100\times12,000}{10}}$$

$$= \sqrt{240,000}$$

= 490 units (Approx).

b) No. of orders/year = $\frac{D}{Q^*} = \frac{12,000}{490}$

= 24.49

c) Time between successive orders

= Q*/D = 490/12,000

0.04 year = .48 month

5.3.2 Manufacturing model without Shortages

Q8. Explain about manufacturing model without shortages.

Ans : **(Aug.-21, Nov.-20, Imp.)**

If a company manufactures its component which is required for its main product, then the corresponding model of inventory is called "Manufacturing model". This model will be with shortages or without shortages. The rate of consumption of items is uniform throughout the year. The cost of production per unit is same irrespective of production lot size. Let,

r = Annual demand of an item

k = Production rate of the item (No. of units produced per year)

C_o = Cost per set up

p = Cost of production per unit.

EBQ be Economic Batch Quantity

The operation of the manufacturing model without shortage is shown in figure.

During the period t1, the item is produced at the rate of k units per period and simultaneously it is consumed at the rate of r units per period. So, during this period, the inventory is built at the rate of k – r units per period. During the period t2, the production of the item is discontinued but the consumption of that item is continued. Hence, the inventory is decreased at the rate of r units per period during this period.

The various formula for this situation are given below

$$EBQ = \sqrt{\frac{2C_or}{C_o(1-r/k)}}$$

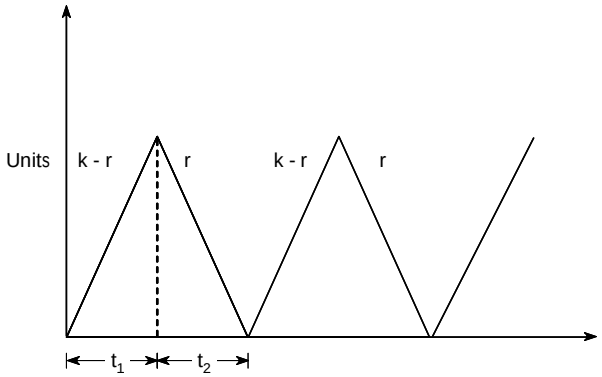


Fig. : Manufacturing Model without stock out

$$t_1^* = Q^*/k = t_2^* = \frac{Q^*[1-r/k]}{r}$$

Cycle time = $t_1^* + t_2^*$

Example

If a product is to be manufactured within the company, the details are as follows :

r = 24,000 units/year

k = 48,000 units/year

Co = ` 200 per set-up

Cc = ` 20/unit/year

Find the EBQ and cycle time.

Sol.:

$$EBQ = \sqrt{\frac{2C_o r}{C_c(1-r/k)}} = \sqrt{\frac{2\times 200\times 24,000}{20(1-24,000/48,000)}}$$

= 980 units (Approx.)

$$t_2^* = \frac{Q^*}{k}$$

= 980/48,000

= 0.02 year = 0.24 month

$$t_1^* = \frac{Q^*}{r}\left(1-\frac{r}{k}\right)$$

$$= \frac{980}{24,000}\left(1-\frac{24,000}{48,000}\right)$$

= 0.02 year = 0.24 month

Therefore,

The cycle time = $t_1^* + t_2^*$

= 0.24 + 0.24

= 0.48 month

5.3.3 Purchase Model with Shortage (Instantaneous Supply)

Q9. Explain about Purchase Model with (Instantaneous Replenishment and with shortages.

Ans : **(Aug.-21, Nov.-20, Imp.)**

In this model, the items on order will be received instantaneously and they are consumed at a constant rate. The purchase price per unit remains same irrespective of order size. If there is no stock at the time of receiving a request for the items, it is assumed that it will be satisfied at a later date with a penalty. This is called back ordering. The operation of this model is shown in figure.

The variables which are used in this model are given below.

D = Demand/period

C_c = Carrying cost/unit/period

C_o = Ordering cost/order

C_s = Shortage cost/unit/period

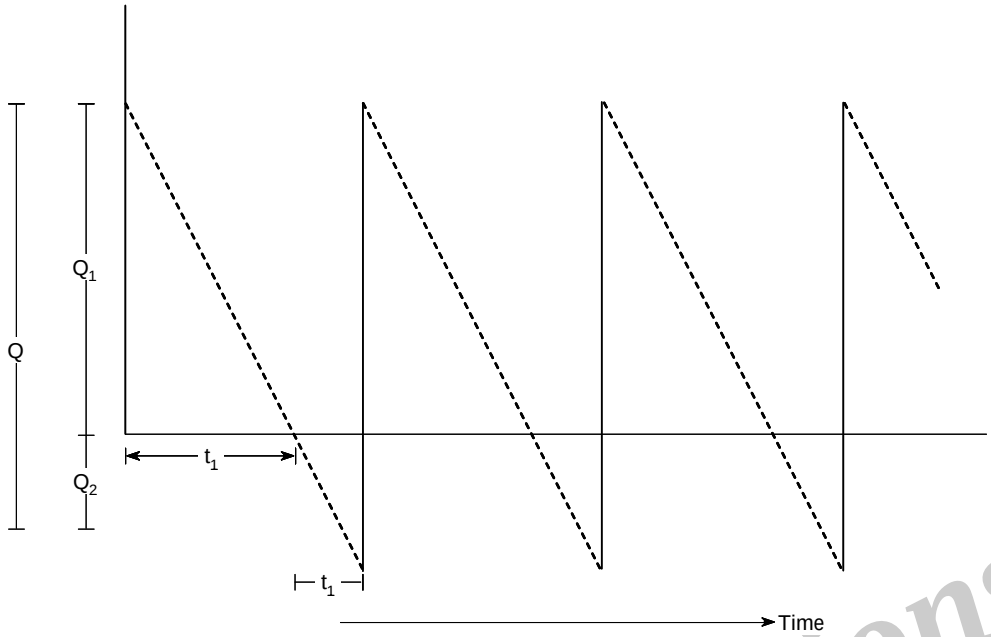


Fig. : Purchase Model of Inventory with Stockout

In the above model

Q = Economic order quantity

Q1 = Maximum inventory, and

Q2 = Maximum stockout

$$Q^* = EOQ = \sqrt{\frac{2C_o D}{C_c}\frac{(C_s + C_c)}{C_s}}$$

$$Q_1^* = \sqrt{\frac{2C_o D}{C_c}\frac{C_3}{C_s + C_c}} = Q^* - Q_2^* = Q^* - Q_1^*$$

$$t^* = Q^*/D$$

$$t_1^* = Q_1^* / D$$

$$t_2^* = Q_2^* / D$$

Example

The annual demand for an automobile component is 24,000 units. The carrying cost is ` 0.40/unit/year, the ordering cost is ` 20.00 per order and the shortage cost is ` 10.00/unit/year. Find the optimal values of the following :

i) Economic ordering quantity.

ii) Maximum inventory.

iii) Maximum shortage quantity.

iv) Cycle time.

v) Inventory period (t_1).

vi) Shortage period (t_2).

Sol.:

D = 24,000 units/year

C_c = ` 0.40/unit/year

C_o = ` 20.00/order

C_s = ` 10.00/unit/year

$$Q^* = EOQ = \sqrt{\frac{2C_oD}{C_c}\frac{(C_s + C_c)}{C_s}}$$

$$Q^* = EOQ = \sqrt{\frac{2 \times 20 \times 24,000}{0.40}\frac{(10 + 0.4)}{10.00}}$$

= 1580 units

$$Q_1^* = \sqrt{\frac{2 \times 20 \times 24,000}{0.40}\frac{10}{(10 + 0.4)}} = 1520 \text{ units}$$

Q_2^* = 1580 – 1520 = 60 units

t* = Q*/D = 1580/24,000 × 365 = 24 days

$t_1^* = Q_1^* / D$ = 1520/24,000 × 365 = 23 days

t_2^* = t* – t_1^* = 24 – 23 = 1 day

5.3.4 Manufacturing Model with Shortage

Q10. Explain about Manufacturing Model with Shortage

Ans : **(Aug.-21, Nov.-20)**

In this model, the items are produced and consumed simultaneously for a portion of the cycle time. The rate of consumption of items is uniform throughout the year. The cost of production per unit is the same irrespective of production lot size. In this model, stockout is permitted. It is assumed that the stockout units will be satisfied from the units which will be produced at a later date with a penalty. This is called backordering. The operation of this model is shown in the figure. The variable which are used in this model are given below. Let,

r = Annual demand of an item

k = Production rate of the item (No. of units produced/year)

C_o = Cost/set up

C_c = Carrying cost/unit/period

C_s = Shortage cost/unit/period

p = Cost of production/unit

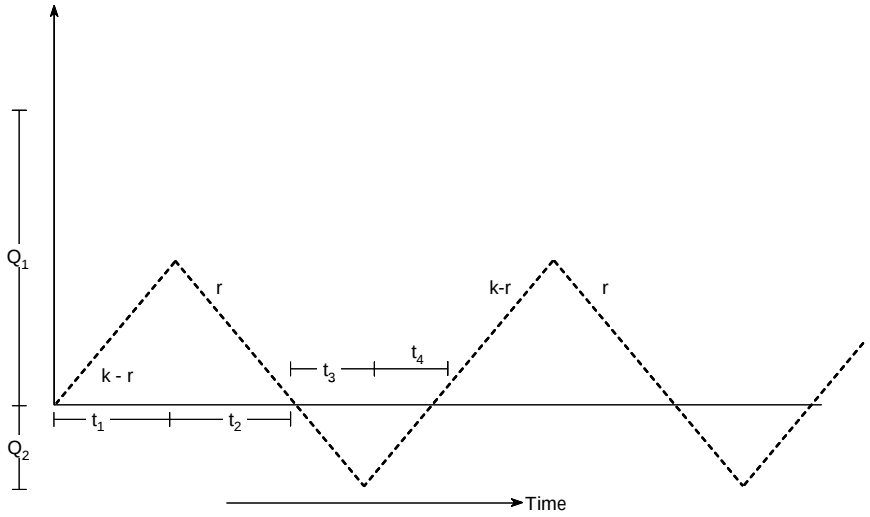


Fig.: Manufacturing Model of Inventory with Stockout

In the above model,

Q = Economic batch quantity
Q_1 = Maximum inventory
Q_2 = Maximum stockout

$$Q^* = EBQ = \sqrt{\frac{2C_o}{(C_c)}\frac{kr}{(k-r)}\frac{(C_c+C_s)}{C_s}}$$

$$Q_1^* = \sqrt{\frac{2C_o}{C_c}\frac{r(k-r)}{k}\frac{C_s}{(C_c+C_s)}}$$

$$Q_2^* = \sqrt{\frac{2C_oC_c}{(C_s(C_c+C_s))}\frac{r(k-r)}{k}}$$

$$Q_1^* = \left(\frac{k-r}{k}Q^*\right) - Q_2^*$$

$t^* = Q^*/r$

$t_1^* = Q_1^* / (k-r)$

$t_2^* = Q_1^* / r$

$t_3^* = Q_2^* / r$

$t_4^* = Q_2^* / (k-r)$

Example

The demand for an item is 18,000 per year. Its production rate is 3000 per month. The carrying cost is ` 0.15/unit/month and the set-up cost is ` 500.00 per set-up. The shortage cost is ` 20.00 per unit per year. Find various parameters of the inventory system.

Sol.:

r = 18,000 units/year

$k = 3000 \times 1\ 2 = 36{,}000$ units / year

C_o = ` 500.00/set-up

C_c = ` (0.15 × 12) = ` 1.80/year

C_s = ` 20.00/unit/year.

$$Q^* = EBQ = \sqrt{\frac{2C_o}{(C_c)}\frac{kr}{(k-r)}\frac{(C_c+C_s)}{C_s}}$$

$$Q^* = EBQ = \sqrt{\frac{2\times 500}{20(1.8+20)}\frac{36,000\times 18,000}{(36,000-18000)}\frac{(1.80+20)}{20}}$$

= 4669 units

$$Q_2^* = \sqrt{\frac{2C_oC_c}{(C_s(C_c+C_s))}\frac{r(k-r)}{k}}$$

$$Q_2^* = \sqrt{\frac{2\times 500\times 1.8}{20(1.8+20)}\frac{18,000(36,000-18,000)}{36,000}}$$

= 193 units

$$Q_1^* = \left(\frac{36,000-18,000}{36,000}4669\right) - 193$$

= 2142 units

t* = Q*/r = 4669/18,000 = 95 days

$t_1^* = Q_1^*/(k-r)$ = 2142/(36,000 – 18,000) = 43.5 days

$t_2^* = Q_1^*/r$ = 2142/18,000 = 43.5 days

$t_3^* = Q_2^*/r$ = 193/18,000 = 4 days

$t_4^* = Q_2^*/(k-r)$ = 193/(36,000 – 18,000) = 4 days

5.4 PROBABILISTIC MODELS OF INVENTORY

Q11. Explain various probabilistic models of inventory.

Ans : **(Feb.-21, Imp.)**

The practical version of purchase model of inventory can be classified into Fixed Order Quantity System (Q System) and Fixed Period Quantity System (P System). These are presented in the following sections.

The following cases exist in each of the systems.

- Varying demand and constant lead time.
- Constant demand and varying lead time.
- Varying demand and varying lead time.

5.4.1 Fixed Order Quantity System (Q System)

Q12. Define fixed order quantity system (Q System).

Ans : **(Feb.-21)**

In this system of inventory, whenever the stock level touches the reorder level, an order is placed for a fixed quantity which is equal to EOQ. A schematic representation of this model is shown in the following Figure.

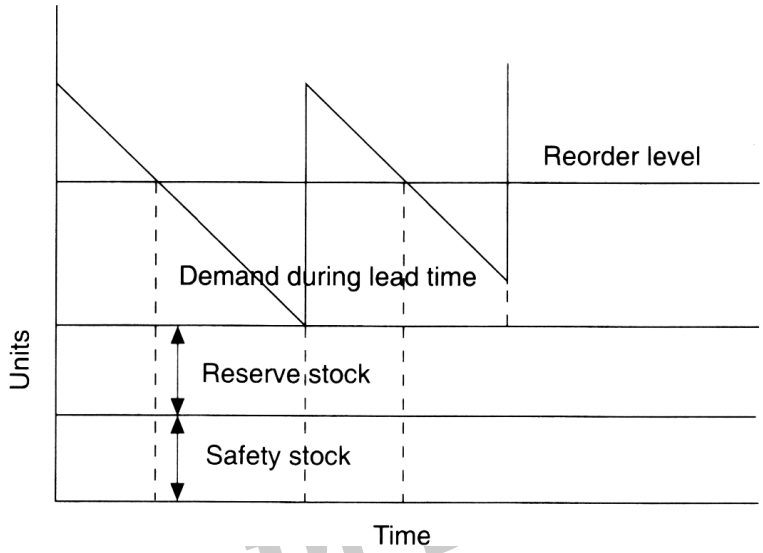


Fig.: Q System of Inventory

The average demand during the lead time (average lead time) is known as the demand during lead time (D_{LX}). The variation in demand during lead time (average lead time) is known as safety stock. The average demand during delivery delays is called reserve stock. The Reorder level is computed as the sum of the demand during lead time (D_{LX}), the variation in demand during lead time (safety stock) and the average demand during delivery delays (reserve stock).

Advantages of Q-system

The advantages of fixed order quantity system or Q-system are as follows,

1. Q-system helps in acquiring the materials in optimum quantity.
2. The use of Q-system helps the inventory managers to place the orders for the items which are required only when needed.
3. Q-system helps in controlling the inventory and maintaining the total inventory investment at the expected level by controlling the planned maximum and minimum values.

Disadvantages of Q-System

Inspite of the above mentioned advantages, Q-system also has certain disadvantages which are as follows,

1. In the Q-system, it is very difficult to order all the inventory items at one period of time due to varying recorder points.
2. The varying order periods may cause inconvenience to the suppliers.

5.4.2 Periodic Review System (P System)

Q13. Define Periodic Review System (P System)

Ans : **(Feb.-21)**

P-system is an inventory control method. P-system is known by different names such as, periodic review system, fixed-order period system, periodic system or fixed order interval system. In this system, the orders are placed at fixed period but the order quantity varies from order to order depending upon the demand in the market. In the Q-system, the order quantity remains same but the period of order differs but in P-system, the order quantity differs but period of order remains the same. In the fixed order period system, the stock position of each type of item is checked at regular intervals. The frequency of reviews differs from firm to firm and from one type of material to other type of material of the same firm.

The figure given below depicts the fixed order period system or P-system.

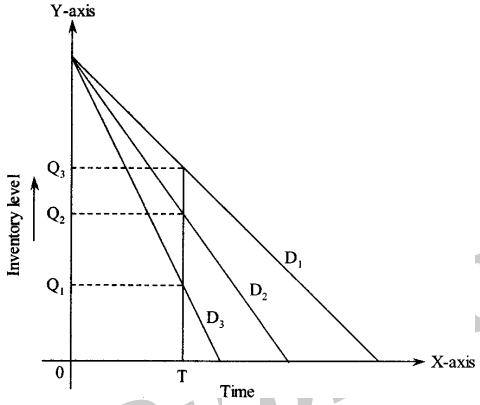


Fig.: Fixed Order Period System or P-system

From the above figure, it is clear that order period is fixed at point 'T' and the order quantity changes from Q_1 to Q_2 to Q_3, Q_1, Q_2 and Q_3, represents quantity ordered at different demand conditions (i.e., D_1, D_2, and D_3).

Advantages

Some of the advantages of P-system are as follows,

1. The use of P-system helps the firms to obtain attractive discounts from the material suppliers as sales are assured in fixed order period system.
2. P-system involves less inventory and ordering costs.
3. P-system is suitable for the materials having seasonal demand and the materials whose procurement has to be preplanned based on the sales forecast.

Disadvantages

The following are the disadvantages of P system

1. Ordering only at fixed period might not be efficient, as there are chances of sudden increase/ decrease in demand or percentage of consumption.
2. As the P-system deals with periodic review system, the inventory manager gets overburdened with the purchasing work around the review dates.
3. Each item has an optimum order quantity based on its price structure, usage rate and attendant internal costs. But as all the items should adequately match with theHimited number of ordering cycles, the actual order quantities varies from economic order quantity in this system.

Example

The annual demand of a product is 48,000 units. The average lead time is 4 weeks. The standard deviation of demand during the average lead time is 75 units/week. The cost of ordering is ` 400 per order. The cost of purchase of the product per unit is ` 10. The cost of carrying per unit per year is 15 per cent of the purchase price. The maximum delay in lead time is 2 weeks and the probability of this delay is 0.25. Assume a service level of 0.95.

(a) If Q system is followed, find the reorder level.

(b) If P system is followed, find the maximum inventory level.

Sol.:

Annual demand, D = 48,000 Units.

Ordering cost per order = ` 400.

Purchase price per unit = ` 10.

Carrying cost per unit per year = 15% of the purchase price

Average lead time = 4 weeks.

Standard deviation of demand during average lead time per week = 75 Units

Maximum delay = 2 weeks.

Probability of having the maximum delay = 0.25

Service level = 0.95

Order quantity = $\sqrt{\frac{2C_oD}{p \times C_c}} = \sqrt{\frac{2 \times 400 \times 48,000}{10 \times 0.15}}$ = 5060 Units

(a) Determination of reorxder level for Q system

Demand during lead time,

D_{LX} = (48,000/52) × 4

= 3692 Units (approx.)

Standard deviation in demand during lead time = (Lead Time)$^{1/2}$ × Standard Deviation per week

= $4^{1/2}$ × 75

= 150 Units

Safety stock during lead time (SS) = K x σ

= 1.64 × 150 = 246 Units,

where K = 1.64 for the given service level of 0.95

Average demand during delivery delays (reserve stock)

$$= \frac{D \times \text{Maximum delay}}{\text{No. of weeks / Yr}} \times \text{Probability of maximum delay}$$

$$= \frac{48,000}{52} \times 2 \times 0.25 = 462 \text{ Units (appro.)}$$

Reorder level = Demand during lead time (D_{LX})
+ Variation in demand during lead time (safety stock)
+ Average demand during delivery delays (reserve stock)
= 3692 + 246 + 462 = 4400 Units.

(b) Determination of maximum inventory level for P system

Review period = EOQID - 5060/48,000 = 0.105 year = 5.46 weeks.

The review period can be either 5 weeks or 6 weeks.

Selection of review period:

Total cost when the review period = 5 week:

Total cost = Ordering cost + Carrying cost

$$= (52/5) \times 400 + \left(\frac{48,000}{52} \times 5\right)/2 \times 10 \times .15$$

= ` 4160 + ` 3462 = ` 7622.

Total cost when the review period = 6 week:

Total cost = Ordering cost + Carrying cost

$$= (52/6) \times 400 + \left(\frac{48,000}{52} \times 6\right)/2 \times 10 \times .15$$

= ` 3467 + ` 4154 = ` 7621.

The total cost is minimum when the review period is 6 weeks. Hence, select the review period as 6 weeks.

Demand during lead time and review period = (48,000/52) × (4 + 6) = 9231 Units (approx.)

Safety stock during lead time and review period

$= (4 + 6)^{1/2} \times \sigma$ per week × K

$= (4 + 6)^{1/2} \times 75 \times 1.64$

= 389 Units

Where

K = 1.64 for the given service level of 0.95

Average demand during delivery delays (reserve stock)

$$= \frac{D \times \text{Maximum delay}}{\text{No. of weeks / Yr}} \times \text{Probability of maximum delay}$$

$$= \frac{48,000}{52} \times 2 \times 0.25$$

= 462 Units

Maximum inventory level = Demand during lead time and review period + Safety stock during lead time and review period + Average demand during delivery delays

= 9231 + 389 + 462

= 10,082 Units.

5.5 Store Management

Q14. Define store management. What are the objectives of store management.

Ans : **(Feb.-21, Aug.-19, Imp.)**

Store is a building where goods are kept, stores is defined as supplies of goods. Storage is defined as the act of storing the goods.

Stores or storage is the function of receiving, storing and issuing materials. It involves the supervision of raw materials, maintaining the goods in good condition, and providing for production when ever required.

Objectives of Store Management

The various objectives of stores management are as follows,

1. To protect the goods available in storage against the losses, in order to verify that the value of this credit is recorded accurately in the book.
2. To make the goods available for on time delivery.
3. To provide low cost services of store keeping to the sales and manufacturing department.
4. To eliminate the storage of raw materials.
5. To ensure that the facilities of storage are located near the operating department.
6. To maintain the required material in adequate quantities.
7. To ensure that materials are not available in excess quantities than required.
8. To buy the materials as per the principle of economic order quantity as it helps in minimizing the associated costs.
9. To ensure that the stores are maintained in clean and good condition.
10. To ensure that unauthorized persons do not enter the stores.

5.5.1 Functions of Stores

Q15. What are the various functions of stores?

Ans : **(Feb.-21)**

The aim of any business activity is to increase the value of the original resources which are risked by owners.

The aim of manufacturing unit is the timely manufacturing of the desired products of specified quality in proper quantities at least possible cost. The efficiency of manufacturing operation largely depends on the efficient functioning of the receiving and stores operations,

To serve these purposes, stores perform following functions,

1. Identification

Identification is the process of systematically defining and describing all items of materials in stock. It involves the preparation of stores code or vocabulary, the adaptation of material specifications and the introduction of a degree of satisfaction.

2. Receipt

It involves checking and accepting from all sources (such as vendors, production units, repair units) that is, all materials and parts which are used in the organization.

3. Inspection

It involves the examination of incoming materials for quality and quantity. Very often, there is a separate quality control or inspection department which undertakes this work for most materials. Otherwise, goods are inspected by stores personnel.

4. Storage and Preservation

These functions are mainly dealt with storing and preserving of incoming materials. Storing is the physical act of storing the materials at appropriate places and preserving involves the maintenance of materials to retain their quality. Quite often, temperature, humidity, dust and other factors cause deterioration of materials.

5. Materials Handling

Materials handling involves movement and handling of materials. This can be manual or mechanical. Heavy items, dangerous or inflammable goods and delicate materials are to be handled differently.

6. Issue and Dispatch

This is the process of receiving demands, selecting the required items and handling them over to users or dispatching them to customers.

7. Inventory Control

Inventory control is the operation of continuously averaging receipts and issues in such as way so as to ensure that stock balance in quantity and for value are adequate to support the current rate of consumption at all times with due regard to economy

8. Stock Taking

It is the process of physical verification of the quantity and condition of goods in store.

Q16. What are the functions of stores management.

Ans : **(Aug.-19, Imp.)**

1. Receiving and Checking

Receiving and checking includes two important duties,

(a) Firstly, inspecting the supplier in terms of both the quality and quantity.

(b) Secondly, preparing documents for,

(i) Posting to stock-records and stores accounts and

(ii) Providing evidence of receipt.

As receiving and inspection is the function at the entry level, accurate information and its documentation is very important.

2. Issue and Dispatch

Issue and dispatch are the outflow functions which involves the issue of an authorized document representing the details of products such as the code number, description, job number or code number of the cost for which quantity is required, quantity issued, authorized person at the time, date of issue and value of items issued.

3. Stockrecords

The objective of maintaining stockrecords is to smoothen the process of material control through gathering and collecting information on the present stock level, consumption level, demand and supply level along with the proper pricing and evaluation of both usage as well as surplus stocks.

4. Stores Accounting

Stores accounting is vital for knowing and depicting the value of stock in the balance sheet and for production cost control. There exist different methods of costing the issues like,

(a) Cost price

(b) Average price

(c) Market price and

(d) Standard price.

Different methods use different procedures and techniques. Therefore, stock accounting is a significant feedback information for the manufacturing process and other materials using departments to judge and evaluate their own efficiency in material usage.

5. Stocktaking and Checking

Stocktaking is necessary to check and monitor the stock records with that of actual estimates. Stocktaking can be performed either on a continuous basis or on a periodic basis. Continuous stocktaking is done throughout the year while periodic stocktaking is done only once in a year. Each and every item must be checked at least once in year. Continuous stocktaking helps in smooth running of the business and the differences between the actual stock and stock records can be easily identified and can be resolved successfully by taking ample time. A complete stock record showing receipts, issues and balances is essential for continuous stocktaking.

6. Stores Arrangement

Materials can be acquired on time through good and proper arrangement and documentation of the storehouses and storing facilities. Stores management must take care of the racks, shelves, bins, empty spaces, spaces for flow of material-handling equipment which should facilitate quick location, drawl and transportation of the required material. Good stores arrangement must possess the following characteristics,

(a) Accurate and exact details of different items that are readily available with the firms.

(b) Items must be quickly and easily available.

(c) Materials-handling equipment and men must be easily moved upon.

(d) Reduced perishability of goods.

(e) Optimum utilization of the stores space.

5.5.2 Material Control

Q17. What is Material Control?

Ans :

Material is an important resource for production process. Ensuring the availability of right quality of material in right quantity at right place at right time and at the right investment is material control.

Objectives of Material Control

The following are the objectives of material control,

1. To ensure continuous supply of materials.
2. To avoid making excessive investment in materials.
3. To reduce the wastage of materials.
4. To follow an effective issue method of materials for reducing the risk of spoilage and obsolescence.
5. To maintain accurate information about the availability of materials.
6. To avoid misappropriation of materials.
7. Tomainta' eliability in the payment of amount to suppliers.

Q18. What are the functions of material control?

Ans :

Material management is a function responsible for coordinating, planning, sourcing, purchasing, moving, storing and controlling materials in an optimum manner so as to provide a pre-decided service to the customer at minimum cost.

Material management in any industry is primarily concerned with materials planning, supply, storage and control of incoming materials costs. It is concerned with activities involved in purchasing,s storage, flow of materials which are directly employed in production and marketing of the finished goods.

The various functions of material control are

i) Materials Planning and Control

Based on the sales forecast and productin plans, the materials planning and control is done. This involves estimating individual requirements of parts, preparation of materials budget, forecasting levels of inventories, scheduling the orders and monitoring the performance in relation to production and sales. While preparing materials procurement plans, macro and micro factors are to be taken into consideration.

Macro Factors

Macro factors which effect the materials planning are price trends, business cycles and goverment policies. These factors are to be kept in mind for fixing levels of inventory while preparing materials plan.

Micro Factors

Micro factors like plant utilization, rejection rate, lead times, inventory levels seasonality of demand are to be taken into consideration at the time of preparing materials plan.

ii) Purchasing

Purchasing includes selection of sources of supply, finalization of terms of purchase, placements of purchase orders, follow up, maintaing smooth relationship with suppliers, approval of payment to suppliers, evaluating and rating of suppliers.

5.5.3 Classification, Codification

Q19. Discuss about Classification Codification.

Ans : **(Sep.-22, Nov.-20, Imp.)**

Classification of Materials

According to ICMA, classification is defined as "the arrangement of items in a logical sequence having regard to their nature (subjective classification) or the purpose to be fulfilled (objective classification)". In simple terms, classification can be defined as the process of arranging or classifying items in groups or sub-groups based on the features of materials.

Codification

It is one of the functions of stores management. Codification is a process of representing each item by a number, the digit of which indicates the group, the sub-group, the type and the dimension of the item. Many organizations in the public and private sectors, railways have their own system of codification, varying from eight to thirteen digits. The first two digits represents the major groups, such as raw materials, spare parts, sub-contracted items, hardware items, packing material, tools, oil, stationery etc. The next two digits indicate the sub-groups, such as, ferrous, non-ferrous etc. Dimensional characteristics of length, width, head diameter etc. constitute further three digits and the last digit is reserved for minor variations.

Methods of Codification of Material

The common code systems, among the many used for stores (materials) are given below:

1. Alphabetic system,
2. Simple numeric or sequence system,
3. Combination system,
4. Block system,
5. Decimal system,
6. Numerical system,
7. Mnemonic system and
8. Six letter – nine letter codes.

1. Alphabetic System

Letters are chosen to represent particular classification. Alphabet code has 26 letters. Each position in the code has 26 possible letters, where relatively few classification are involved, assignment of letter designates is sometimes arbitrarily made.

2. Simple Numeric or Sequence System

Numbers are assigned for classification. The obvious disadvantage of this simple numerical sequence is that there are no memory adds incorporated in the system. A good deal of time is wasted in aching for code numbers in materials code books.

3. Combination System

Some firms find it advantageous to combine a mnemonic and numerical or decimal system.

4. Block System

Blocks of numbers are reserved for specified classifications such as 1700-1799 for the raw materials and 1800-1899 for manufacturing parts, etc. The advantage by doing so is that wherever numbers are not assigned, subsequent expansion can be accommodated.

5. Decimal System

Numbers are assigned in such a manner that each digit represents a sub-group or sub-account of the previous digit. The principal advantage of a decimal system is its capacity to accommodate a new item. The disadvantage is that it becomes cumbersome when a basic unit has many minor assemblies which in turn consists of numerous subassemblies.

6. Numeric System

The first or basic numbers indicate specific classes with subsequent digits used to describe sub-classifications.

7. Mnemonic System

It is an alphabetic system designed with an objective of easy memorization.

8. Six Letter or Nine Letter Codes

This system is widely adopted and is of immense use.

Advantages of Codification

To identify correctly, to avoid multiplication of items, to save time and labour, to facilitate easy location and proper functioning of the storehouse, a proper codification is to be evolved so as to obtain the following benefits:

1. To avoid long and unwieldy description.
2. To have accurate and logical identification.
3. To prevent duplication.
4. To standardize items.
5. To reduce varieties.
6. To have an efficient purchasing department.
7. To obtain efficiency in recording and accounting.
8. To simplify and facilitate mechanical recording.
9. To simplify and facilitate pricing.
10. To have proper system of location and indexing.
11. To assure correct and efficient inspection; and
12. To implement production as planned.

5.6 Standardization of Materials

Q20. Discuss about Standardization of materials

Ans : **(Sep.-22, Nov.-20, Imp.)**

Standardization

Standardization is a procedure in which rules are developed and used for a systematic approach to a specific activity with cooperation of all related parties in order to benefit and enhance the optimum overall economy by considering functional conditions and safety requirements. Standardization depends on the combined results of science, techniques and experience. It is not only emphasizing on the present but also focuses on future development'.

Classification of Standardization

Standardization is a design activity which eliminates the variations among the group of products or parts. It results in the production of high quantity of each product which causes low production costs, improves the quality of product and reduces inventory and easy automation. The functional classification of standardization is based on the following functions,

1. Units and Measurements

International system of units was developed to have single system of units which was summarized as S.I units. The primary S.I units comprise of six basic units two supplementary units and 27 derived units. Precision measurement is now considered as a distinct field of engineering known as Metrology. BIPM (Bureau International Des poids et Measure), an international authority was formed to sustain the measuring standards of physical quantities. International Organization of Legal Metrology was developed in 1956 to secure, safeguard and maintain the standards of units and measurement.

2. Grouping and Grading

In this, different varieties of products are grouped with specific grades based on their specification or end use. But for some products grouping and grading is done on the basis of dimensions or power rating.

3 Specification and Tolerance

While designing the products and processes, the standardization of specification and tolerance plays an important role Usually, specifications are of three types: Obligatory, Optional and Informative. Specifications are usefi.il for legal, commercial and technical purposes and guides all the sections of society like manufacturers, traders and users.

4. Inspection and Sampling

In order to protect the interests of both the buyers and sellers and to have quality assurances, standard of inspection and sampling are used. These standards reduce the costs by avoiding rework and by decreasing the number of defects.

5. Quality and Testing

Standards of Testing are needed for quality, uniformity and interchangeability of products which forms a part of specification. Testing is considered as the most essential factor of standardization which is done by measuring the given parameters.

6. Variety Reduction

Variety Reduction deals with reducing the number of products and processes along with the number of groups, grades and classes of those products, processes, materials and components. While reducing the variety, OR techniques are used along with discretion because if the restriction exceeds then it becomes counter productive and effects the consumer interest. The OR techniques used in variety reduction are: (i) Frequency distribution and (ii) Preferred number systems.

7. Packaging and Labelling

Packaging and Labelling are the essential part of standard specification. Packaging has now gained much importance and emerged as a separate discipline. Several efforts are made for attain in a uni form standard of labelling which helps the consumers. Labelling acts as a certificate of quality and quantity of contents. It has become compulsory to label the dangerous goods such as explosives etc.

8. Legal and Standard Practice (code)

When quality completely satisfies the consumers then it is termed as Total Quality Control (TQC). It deals with standardization of many activities both in legal aspects as well as in standard practices or code of conduct. Some legal aspects are agreement, termination, compensation for services rendered, modification of agreement etc. Standard practices (codes) involve both technical and non-technical areas like, safety of employees, wastage control, environmental protection, training and development etc., which need to be standardised.

9. Forms and Contracts

Contracts are an important element of agreement. It can be classified into technical, commercial or financial contracts. Standardization of contracts involves a lot of confusion as it makes use of different forms. The level of confusion increases in bilateral contracts which deal with different countries and different banks. "Sine qua non" is a type of standardization used in banking and commercial transactions for globalizing the industries and internationalizing the business.

Q21. What are the advantages, applications of standardization?

Ans : **(Nov.-20, Imp.)**

Advantages of Standardization

The advantages gained from standardization procedure are as listed below:

- Fewer specifications, drawings and part lists have to be prepared and issued.
- Better quality products.
- Lower unit costs.
- Increased margin of profit.
- Easy availability of spares.
- Minimum inventory cost.
- Quantity discounts are possible because of purchase of raw materials in large volume.

Application of Standardization

Standardization can be applied to a major extent in the following 'fields:

- Finished products, e.g. cars and televisions.
- Sub-assemblies and components, e.g. automobile gearboxes and auto-electric bulbs.
- Materials, e.g. both direct materials (plain carbon and alloy steels, welding electrode, core wire, etc.) and indirect materials such as oils and greases.
- Production equipments, e.g. that of machine tools, press, welding equipments, etc.

5.7 SIMPLIFICATION

Q22. Define Simplication

Ans :

Simplification

Simplification is the first step of standardization. It is the process which deals with minimizing different types of manufactured products. It helps in minimizing product range, assemblies, parts, materials and design.

Simplification is beneficial to manufacturers, suppliers and buyers. It carries out the advantages of reduced inventory, better plant utilization, greater use of storage space and reduction of buying/selling efforts to manufacturers. It makes suppliers to focus on the sale of fewer items. Thus, they can maximise their turnover. Finally buyers can experience better after sales service with this process of simplification followed by the manufacturers.

Simplification means elimination of superfluous varieties, sizes, dimensions, etc. Product simplification means reducing the number of varieties. The other names for simplification are unification or variety reduction.

Simplification will be advantageous to manufacturers, suppliers and buyers. Reduced inventory, better plant utilization, greater use of storage space, reduction of buying/selling efforts are the advantages to manufacturers. Suppliers can concentrate on the sale of fewer items and thereby increase their turnover. Buyers can have better after sales services due to the use of less number of parts. Simplification is the first step towards standardization.

Considerations in simplifying items

1. Can simplification be effectively achieved depending upon the nature of item?
2. How simplification will affect customer demand and volume of sale?
3. Does market competition permit simplification or it encourages product diversification?

5.8 BIN CARD, DOUBLE BIN AND STORES LEADER

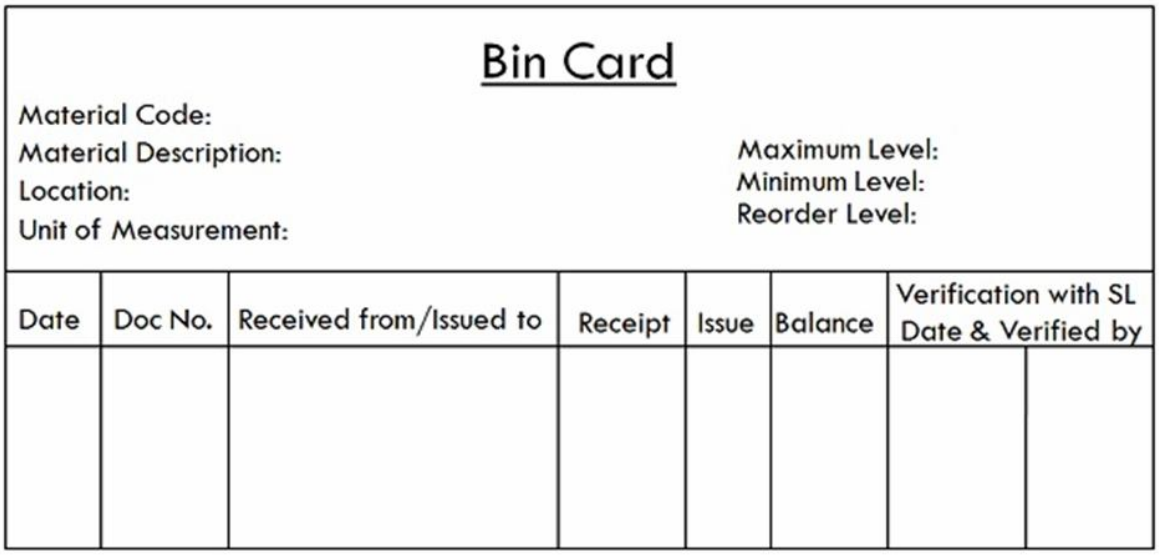
Q23. Explain about Bin Card, Double Bin and Stores Leader.

Ans :

A) Bin Card

Bin is a place where materials are kept in. It may be a rack, container, shelf or space where stores are kept. Bin card is a document showing the particulars of materials kept in the bin. It is a document attached to the bin disclosing the quantitative details of materials received, issued and the closing balance. A bin card is used for each item of material. Each receipt and issue is recorded on the bin card in a chronological order and the latest balance is shown after each receipt and issue. Bin card is maintained by the store keeper. It indicates information like different stock levels. No, name of material, material code number, stores ledger folio number, quantity of materials received, issued and the balance in hand.

Bin Card



Bin Card

Material Code:
Material Description:
Location:
Unit of Measurement:

Maximum Level:
Minimum Level:
Reorder Level:

Date	Doc No.	Received from/Issued to	Receipt	Issue	Balance	Verification with SL Date & Verified by	

Advantages of Bin Cards

(i) There would be less chances of mistakes being made as entries will be made at the same time as goods are received or issued by the person actually handling the materials.

(ii) Control over stock can be more effective, in as much as comparison of the actual quantity in hand at any time with the book balance is possible.

(iii) Identification of the different items of materials is facilitated by reference to the Bin Card the bin or storage receptacle.

Disadvantages of Bin Cards

(i) Store records are dispersed over a wide area.

(ii) The cards are liable to be smeared with dirt and grease because of proximity to material and also because of handling materials.

(iii) People handling materials are not ordinarily suitable for the clerical work involved in writing Bin Cards.

B) Two Bin System

Two bin system is used for the material control. It is that technique of material control in which we have two bins, one is used for in use minimum stock and second bin is used for reserve stock or to keep the remaining quantity of material. This system of inventory control is also called in USA kanban. First bin is utilized for issuing the material for production and then, second bin is used. Its record is done on bin cards and store ledger card.

Two bin systems are common on assembly and moving manufacturing lines where components are added to the product or item being built. The two bin system is just like its name suggests, it is

composed of two bins which are full of components or materials to start. As production commences one bin is drawn down of materials and the other bin, which is still full, acts as the buffer or safety stock.

When the first bin is completely depleted the worker or assembly line worker switches to the other bin, similar to a FIFO system. The switch of bins can be interpreted as a kanban signal for the supply process of that particular component to manufacture or supply the component just in time before the second bin runs out of material. The kanban signal can also be generated half way throughout the first bin, depending on lead times for the component to be supplied.

This system in a way is similar to the EOQ inventory model with safety stock. It is a very common system used in vehicle manufacturing plants. The size or number of components in each bin is usually determined using the EOQ inventory model or a time period model.

Two-bin inventory control

Two-bin inventory control involves the storage of goods in two bins, one of which contains working stock and the other containing reserve stock. The amount of inventory kept in the reserve stock bin equals the amount the company expects to use during the ordering lead time associated with that item. To use this system, reorder goods as soon as the working stock bin is empty, and replacement parts should arrive before the reserve stock bin is empty. It is possible to fine-tune the inventory investment by altering the amount of goods kept in the reserve stock bin. The calculation for the amount of inventory to keep in the reserve stock bin is:

(Daily usage rate × Lead time) + Safety stock = Reserve bin quantity

For example, a company experiences weekly usage of 500 units of a purple cell battery, so the daily usage rate is 100 units. The lead time for the battery is three days. The reserve storage bin should contain at least 300 batteries, to cover expected usage during the three-day lead time. In addition, the company assumes that usage levels can vary by as much as 25% from the average usage rate. Consequently, 75 additional batteries are kept in the reserve storage bin. This is calculated as 300 reserve units × 25% safety stock allowance. Thus, the total reserve stock is 375 units.

Two-bin inventory control is commonly used for low-value items that can be purchased and stored in bulk, and for which stocks are maintained in the production area, rather than the warehouse. More expensive inventory items are controlled with a perpetual inventory system.

C) Store Ledger

Store ledger is a document showing the quantity and value of materials received, issued and in balance at the end. One stores ledger is allotted to each component of material. Entries are made in this ledger by the costing clerk with reference to goods received note, material requisition note, material returned note etc. It is very similar to the bin card except it contains additional columns showing the prices and value of materials received, issued and balance in hand. It gives the value of closing stock at any time. Besides, a store ledger contain information like name of the material, code number, different stock levels etc.

Stores Ledger

Stores Ledger

Material Code:
Bin No.:
Material Description:
Location:

Maximum Qty:
Minimum Qty:
Ordering Qty:

Date	Receipts				Issues				Balance		
	GR No	Qty	Rate	Amount	SR No	Qty	Rate	Amount	Qty	Rate	Amount

5.8.1 Difference between Store Ledger and Bin Card

Q24. What are the difference between Store Ledger and Bin Card ?

Ans :

Difference between Store Ledger and Bin Card

Stoer Ledger	Bin Card
1. It is a record of both quantity and value.	1. It is a record of quantity onty.
2. It is maintained by the cost clerk.	2. It is maintained by the storekeeper.
3. It is kept in the cost office.	3. It is attached to the bin.
4. Entiles are made by the cost clerk.	4. Entries are mode by Ibe store keeper.
5. Entries are made on the basis of documents like goods received note, material requisition note etc.	5. Entries are made on the basis of actual quantity received and issued.
6. Posting are made after the transactions.	6. Postings are made before the transactions.
7. Transactions are periodically recorded.	7. Individual transactions are recorded.
8. Inter departmental transactions are recorded for costing purpose.	8. Inter departmental transfers are not shown.
9. Facilitates physical verification of closing stock.	9. Facilitates physical verification of closing stock

5.9 Selective Inventory Control - ABC, XYZ, VED, FNS And SDE Analysis

Q25. Discuss about Techniques of Inventory Control.

Ans : **(Aug.-21, Jan.-18, Imp.)**

Selective Treatment

Selective control means variations in method of control from item to item based on selective basis. The criterion used for the purpose may be cost of the item, criticality, lead time, consumption, procurement difficulties, or something else. Various classifications are employed to render selective treatment to different types of materials, each classification emphasizes on a particular aspect. For example, ABC analysis emphasizes usage value (i.e. consumption of the items in terms of money), VED analysis considers criticality; HML employs price criterion; and SDE analysis is based on procurement difficulties.

Table : Types of Classification of Inventory Control

Criterion	Employed
1. ABC analysis	Usage value (i.e. consumption per period X price per unit)
2. HML analysis (High-Medium-Low)	Unit price (i.e. it does not take consumption into account)
3. VED analysis (Vital-Essential- Desirable)	Criticality of the item (i.e. loss of production)
4. SDE analysis (Scrace-Difficult-Easy)	Procurement difficulties
5. GOLF analysis (Government-Ordinary-Local-Foreign)	Source of procurement
6. SOS analysis (Seasonal-Of-Seasonal)	Seasonality
7. FSN analysis (Fast-Slow-Non-moving)	Issues from stores
8. XYZ analysis	Inventory investment

1. ABC Analysis

ABC analysis underlines a very important principle "Vital few : trivial many". Statistics reveal that just a handful of items account for bulk of the annual expenditure on materials. These few items, called 'A' items, therefore hold the key to business. The other items, known as 'B' and 'C' items, are numerous in number but their contribution is less significant. ABC analysis thus tends to segregate all items into three categories : A, B and C on the basis of their annual usage. The categorisation so made enables one to pay the right amount of attention as merited by the items.

A-Items : It is usually found that hardly 5-10% of the total items account for 70-75% of the total money spent on the materials. These items require detailed and rigid control and need to be stocked in smaller quantities. These items should be procured frequently, the quantity per occasion

being small. A healthy approach, however, would be to enter into contract with the manufacturers of these items and have their supply in staggered lots according to production programme of the buyer. This, however, will be possible when the demand is steady. Alternatively, the inventory can be kept at minimum by frequent ordering.

B-Items : These items are generally 10-15% of the total items and represent 10-15% of the total expenditure on the materials. These arc intermediate items. The control on these items need not be as detailed and as rigid as applied to C items.

C-Items : These are numerous (as many as 70-80% of the total items), inexpensive (represent hardly 5-10% of the total annual expenditure on materials) and hence insignificant (do not require close control) items. The procurement policy for these items is exactly the reverse of A items. C items should be procured infrequently and in sufficient quantities. This enables the buyer to avail price discounts and reduce work load of the concerned departments.

Conducting ABC analysis

To conduct ABC analysis, following six steps are necessary :

(a) Prepare the list of the items and estimate their annual consumption (units).

(b) Determine unit price (or cost) of each item.

(c) Multiply each annual consumption by its unit price (or cost) to obtain its annual consumption in rupees (annual usage).

(d) Arrange items in the descending order of their annual usage starting with the highest annual usage down to the smallest usage.

(e) Calculate cumulative annual usages and express the same as cumulative usage percentages. Also express the number of items into cumulative item percentages.

(f) Graph cumulative usage percentages against cumulative item percentages and segregate the items into A, B and C categories.

To segregate items into A, B and C categories, first few items which contribute between 70-75% of cumulative usage can be considered as A category, next few items which together with A category of items segregated earlier contribute between 80-90% of cumulative usage can be considered B category, and left over items can be taken as C-category.

2. HML Analysis

H-M-L analysis is similar to ABC analysis except for the difference that instead of "usage value", "price" criterion is used. The items under this analysis are classified into three groups which are called "High", "Medium" and "Low". To classify, the items are listed in the descending order of their unit price. The cut-off-lines are then fixed by the management for deciding three categories. For example, the management may decide that all items of unit price above Rs. 1000 will be of 'H' category, those with unit price between Rs. 100 to Rs. 1000 will be of 'M' category and those having unit price below Rs. 100 will be of 'L' category.

HML analysis helps to

- assess storage and security requirements (e.g. high priced items like bearings, worm shafts, worm wheels, etc. require to be kept in the cupboards).
- to keep control over consumption at the departmental head level (e.g. indents of high and medium priced items are authorised by the departmental head after careful scrutiny of the consumption figures).
- determine the frequency of stock verification, e.g. high priced items are checked more frequently than low priced items.

- to evolve buying policies to control purchases e.g. excess supply than the order quantity may not be accepted for "H" and "M" groups while it may be accepted for "L" group.
- to delegate authorities to different buyers to make petty cash purchase e.g. "H" and "M" category of items may be purchased by senior buyers and "L" category of items by junior buyers.

3. VED Analysis

VED analysis represents classification of items based on their criticality. The analysis classifies the items into three groups called Vital, Essential and Desirable. "Vital" category encompasses those items for want of which production would come to halt. "Essential" group includes items whose stakeouts cost is very high. And "Desirable" group comprises of items which do not cause any immediate loss of production or their stockout entail nominal expenditure and cause minor disruptions for a short duration.

VED (Vital-Essential 1-Desirable) analysis is carried out to identify critical items. An item which usagewise belongs to C-category may be critical from production point of view if its stockout can cause heavy production loss.

An item may be vital for a number of reasons, namely

- if the non-availability of the item can cause serious production losses.
- lead time for procurement is very large.
- it is non-standard item and is procured to buyer's design.
- the sources of supply is only one and is located far off from the buyer's plant.

Steps involved in making VED analysis are as under :

(i) Identify the factors to be considered for VED analysis. The commonly considered factors are : effect on production (i.e. stock out cost in the event of its non-availability), lead time, nature of the item and sources of supply.

(ii) Assign points/weightages to the factors according to their importance to the company. Typical examples of the weightages to the above four factors may be 30,30,20 and 20 points.

(iii) Divide each factor into three degrees and allocate points to each degree. Usually, the first degree is assigned points equal to the weightage of its factor; second degree is allocated points equal to twice the weightage of the factor and third degree is assigned points equal to thrice the weightage of the factor.

(iv) Prepare categorisation plan (Table) which provides the basis of classification of items into vital, essential and desirable categories.

(v) Evaluate items one by one against each factor and assign points to the item depending upon the extent of presence of the factor in the item.

(vi) Place the items into V, E and D categories depending upon the points scored by them (Table 29.3) and basis of classification set under step (iv).

Table : Typical VED analysis categorisation plan

	Factor	First degree	Second degree	Third degree
1.	Stockout cost in the event of non-availability (30)	Above Rs. x (30)	Between Rs. x to y (60)	Above Rs. y (90)
2.	Lead time for procurement (30)	1 -4 weeks (30)	4-8 weeks (60)	Over 8 weeks (90)
3.	Nature of the item (20)	Produced to commercial standard, or off the shelf availability (20)	Produced to suppliers' design (40)	Produced to buyer's design or proprietory items (60)
4.	Sources of supply (20)	Local (20)	Outstation (40)	Imported, quota items i.e. controlled supply (60)

Table : Typical categorisation plan

Points	Classification
100-160	Desirable
161-230	Essential
231-300	Vital

VED analysis is best suited for spares inventory. In fact, it is advantageous to use more than one method, e.g. ABC and VED analysis together would be helpful for inventory control of spares.

4. S-D-E Analysis

S-D-E analysis is based on the problems of procurement namely :

- non-availability
- scarcity
- longer lead time
- geographical location of suppliers, and
- reliability of suppliers, etc.

S-D-E analysis classifies the items into three groups called "Scarce", "Difficult" and "Easy". The information so developed is then used to decide purchasing strategies.

"Scare" classification comprises of items which are in short supply, imported or cannalised through government agencies. Such items arc best to procure limited number of times a year in lieu of effort and expenditure involved in the procedure for import.

"Difficult" classification includes those items which are available indigeneously but are not easy to procure. Also items which come from long distance and for which reliable sources do not exist fall into this category. Even the items which are difficult to manufacture and only one or two manufacturers are available belong to this group. Suppliers of such items require several weeks of advance notice.

"Easy" classification covers those items which are readily available. Items produced to commercial standards, items where supply exceeds demand and others which are locally available fall into this group.

S-D-E analysis is employed by the purchase department:

(i) To decide on the method of buying: e.g. Forward buying method may be followed for some of the items in the "Scarce" group; "scheduled buying" and "contract buying" for "Easy" group.

(ii) To fix responsibility of buyers: e.g. Senior buyers may be given the responsibility of "S" and "D" groups while items in "E" group may be handled by junior buyers or even directly by the storekeeper.

5. G-NG-LF ANALYSIS / GOLF ANALYSIS

G-NG-LF analysis (or GOLF analysis) like S-D-E analysis based on the nature of the suppliers which determine quality, lead time, terms of payment, continuity or otherwise of supply and administrative work involved. The analysis classifies the items into four groups namely G-NG-L and F.

"G" group covers items procured from "Government" suppliers such as the STC, the MMTC and the public sector undertakings. Transactions with this category of suppliers involve long lead time and payments in advance or against delivery.

"NG" (O in GOLF analysis) group comprises of items procured from "Non-Government" (or Ordinary) suppliers. Transactions with this category of suppliers involve moderate delivery time and availability of credit, usually in the range of 30 to 60 days.

"L" group contains items bought from "Local suppliers". The items bought from local suppliers are those which are cash purchased or purchased on blanket orders.

"F" group contains those items which purchased from "Foreign" suppliers. The transactions with such suppliers :

- involve a lot of administrative and procedural work.
- necessitate search of foreign suppliers.
- require opening of letter of credit.
- require making of arrangement for shipping and port clearance.

6. S-OS Analysis

S-OS analysis is based on seasonality of the items and it classifies the items into two groups S (seasonal) and OS (i.e. Off Seasonal). The analysis identifies items which are :

(i) seasonal and are available only for a limited period. For example agriculture produce like raw mangoes, raw materials for cigarette and paper industries, etc. are available for a limited time and therefore such items are procured to last the full year.

(ii) seasonal but are available throughout the year. Their prices, however, are lower during the harvest time. The quantity of such items requires to be fixed after comparing the cost savings due to lower prices if purchased during season against higher cost of carrying inventories if purchased throughout the year.

(iii) non-scasonal items whose quantity is decided on different considerations.

7. M-N-G Analysis

M-N-G analysis based on stock turn over rate and it classifies the items into M (Moving items), N (Non-moving items) and G (Ghost items.)

M (moving items) are those items which are consumed from time to time. N (Non-moving items) are those which arc not consumed in

the last one year. G (Ghost items) are those items which had nil balance, both in the begining and at the end of the last financial year and there were no transactions (receipt or issues) during the year.

Analysis mainly helps to identify non-existing items for which the store keeps bin-cards or waste computer memory or waste computer stationary while preparing stores ledger. Stores department even might have even car-marked space for these non-existent items.

All pending / open purchase orders (if any) of such items should be cancelled.

8. F-S-N Analysis

F-S-N analysis is based on the consumption figures of the items. The items under this analysis are classified into three groups : F (fast moving), S (low moving) and N (non-moving)

To conduct the analysis, the last date of receipt or the last date of issue whichever is later is taken into account and the period, usually in terms of number of months, that has elapsed since the last movement is recorded.

Such an analysis helps to identify :

(i) Active items which require to be reviewed regularly.

(ii) Surplus items whose stocks are higher than their rale of consumption; and

(iii) Non-moving items which arc not being consumed. The last two categories are reviewed further to decide on disposal action to deplete their stocks and thereby release company's productive capital.

Further detailed analysis is made of the third category in regards to their year-wise stocks and items can be sub-classified as non-moving for 2 years, non-moving for 3 years, non-moving for 5 years and so on.

9. X-Y-Z Analysis

X-Y-Z analysis is based on value of the stocks on hand (i.e. inventory investment). Items whose inventory values are high arc called X items while those whose inventory values are low are called Z items. And Y items are those which have moderate inventory stocks.

Usually X-Y-Z analysis is used in conjunction with cither ABC analysis or HML analysis.

XYZ analysis when combined with ABC analysis is used as under :

Class of items	A	B	C
X	Efforts to be made reduce stocks to Z category	Efforts to be made to convert them to Y category	Steps to be taken to dispose off surplus stocks
Y	Efforts to be made convert these to Z category	*	Control may be further tightened
Z	*	Stock levels may be reviewed twice a year	*

X Y Z analysis when combined with F S N analysis helps to formulate more specific strategies as under:

Class of items	F	S	N
X	Tighen control	Deplete stocks to very low level.	Dispose off immediately at optimum price.
Y	*	Deplete the stocks further at good price	Dispose off as early as possible
Z	Liberalise control (to reduce clerical cost)	*	Dispose off as early as possible even at lower prices.

* Items are within control. No further action is necessary.

XYZ, therefore, helps to identify a few items which account for large amount of money lockedup in stock and lake steps for their liquidation / reduction.

XYZ when combined with FSN analysis helps to classify non-moving items into XN, YN and ZN group and thereby identify a handful of non-moving items which account for bulk of non-moving stock. These can be studied individually in details to take decision on their disposal or retention.

PROBLEMS ON INVENTORY CONTROL

1. A manufacturing company purchases 9,000 parts of a machine for its annual requirements, ordering one month usage at a time. Each part costs Rs.20 The ordering cost per order is Rs.15 and the carrying charges are 15% of the average inventory per year. You have been asked to suggest a more economical purchasing policy for the company. What advice would you offer and how much would it have the company per year ?

Sol :

Annual demand,

$D = 9000$ units.

Ordering cost per order

$C_0 = Rs.15$

Purchase price,

$C = Rs. 20$

Inventory carrying charge,

$1 = 15\%$

$\therefore$ Inventory carrying cost,

$C_C = CX1 = 20 \times 0.15 = Rs. 3$

Economical Purchasing Policy

$$EOQ = Q^* = \sqrt{\frac{2DC_0}{C_C}} = \sqrt{\frac{2\times 9000\times 15}{3}} = 300 \text{ units}$$

Total annual cost

$$= \frac{D}{Q^*} C_0 + \frac{Q^*}{2} C_h + Dc$$

$$= \frac{9000}{300}\times 15 + \frac{300}{2}\times 3 + 9000\times 20$$

= Rs. 1,80,900

Current Ordering Policy :

Q = One month usage

$$= \frac{9000}{12} = 750 \text{ units}$$

Total annual cost

$$= \frac{D}{Q} C_0 + \frac{Q}{2} C_h + DC$$

$$= \frac{9000}{750}\times 15 + \frac{750}{2}\times 3 + 9000\times 20$$

= Rs. 1,81,305.

Total Cost

EOQ Policy = Rs. 1,80,900.

Current policy = Rs. 1,81,305.

As EOQ policy provides least total annual cost, the advice to the company would be to go for economic purchase policy of ordering 300 units each time.

Saving to the company per year due to EOQ is Rs. 4051.

2. Abhi industry estimates that it will sell 24,000 units of its product for the forth coming year. The ordering cost is Rs. 150 per order and the carrying cost per unit per year is 20% of the purchase price per unit. The purchase price per unit is Rs. 45. Find out economic order quantity, number of orders per year, time between successive orders and total annual cost.

Sol :

Given

Demand,

D = 24,000 units/year

Ordering cost,

C_0 = Rs. 150 / order

Carrying, $C_C = C \times 1$

Cost of item, C = Rs. 45

Inventory carrying charge I = 0.2

$\therefore \quad C_C = 45 \times 0.2 = 9$

i) EOQ (Q*) = $\sqrt{\frac{2DC_0}{C_C}} = \sqrt{\frac{2 \times 24000 \times 150}{9}}$ = 894.4 $\cong$ 894 units.

ii) Number of orders per year N = $\frac{D}{Q^*} = \frac{24000}{894} = 27$ orders

iii) Time between successive orders T = $\frac{365}{N} = \frac{365}{27} = 13.5$ days

iv) Total annual cost = $\frac{D}{Q^*} C_0 + \frac{Q^*}{2} C_C + DC$

$= \frac{2400}{894} \times 150 + \frac{894}{2} \times 9 + 24000 + 45$

= 4027 + 4023 + 10,80,000

= Rs. 10,88,050.

3. Annual demand for an item is 5400 units. Ordering cost is Rs. 600 per order. Inventory carrying cost is 30% of the purchase price per year. The price breaks are as shown below :

Quantity	Price (Rs.)
$0 \le Q_1 \le 2400$	12
$2401 \le Q_2 \le 3000$	10
$Q_3 \le 3001$	8

i) Find the EOQ.

ii) Find the optimal order size.

Sol :

Monthly demand = 5400 units

Ordering cost = 600

Inventory carrying cost = 30% of the purchasing price per unit per year

b_1 = 2400 ; b_2 = 3000

p_1 = 12 ; p_2 = 10 ; p_3 = 8

$$EOQ = \sqrt{\frac{2\times5400\times600}{0.3\times12}} = 1342 \text{ units}$$

$$TC\ (Q_1) = \frac{5400}{2400}\times600 = 1350$$

$$TC\ (Q_2) = \frac{5400}{3000}\times600 = 1080$$

Recording point is between 1080 and 1350.

4. A firm has a demand distribution during a constant lead time with a standard deviation of 400 units. The firm wants to provide 95 percent side.

i) How much safety stock should be carried ?

ii) If the demand during lead time averages 1500 units what is the appropriate reorder level ?

Sol :

Standard deviation = 400 units

Recorder level = ?

Safety stock = ?

Demand during lead time = 1500 units.

For 95% of the confidence, safety stock to be maintained is equal to two times standard deviation.

Safety stock = 2 × 450 = 900 units

Reorder level = Safety stock + Average demand during lead time

= 2400 units.

5. In a foundry which manufactures light castings, moulds are prepared by machine moulding process. The average cycle time for machine moulding per mould is 6 minutes. Envisaged rate of production is 20,000 pieces of castings per month. Determine the number of machines required to meet the production plan. Assume necessary data after stating the reasons for assumption.

Sol :

Average cycle time for machine moulding per mould = 6 min

Rate of production = 20,000 pieces of castings per month

Time required to produced

20,000 pieces = 30 × 24 5 60 min

No.of machines required

$$= \frac{30\times24\times60}{6} = 30\times24\times10$$

= 7200 assuming that it is continuous production.

6. A factor uses annually 24000 units of raw materials which costs Rs. 1.25 per unit. Placing each order cost Rs. 25/- and carrying cot is 6% per year of the average inventory.

i) Find the EOQ and the total inventory cost including the cost of material.

ii) The factory works for 320 days a year. If the procurement time is 10 days and safety stock is 450 units, find the re-order point. The minimum, maximum and averages inventories.

Sol :

(i) Cost of raw material = 24,000 × 1.25

= 30,000 Rs.

Placing order cost = 25

Carrying cost = 6%

$$EOQ = \sqrt{\frac{2DC_0}{IP}} = \sqrt{\frac{2 \times 24,000 \times 25}{1.25 \times 6\%}} = \sqrt{\frac{12,00,000}{0.075}} = 4000 \text{ units}$$

Total inventory cost per year

= Cost of materials per year + Ordering cost per year

+ Inventory carrying cost per year

$$= DC + \frac{D}{Q^*} C_0 + \frac{Q^*}{2} C_h$$

$$= 24,000 \times 1.25 + \frac{24,000}{4,000} \times 25 + \frac{4,000}{2} \times 0.075$$

$$= 30,000 + 1.50 + 150 = 30,300$$

(ii) Daily usage $= \frac{\text{Annual demand}}{\text{Number of working days per year}} = \frac{24,000}{320} = 75$ units

Lead time = 10 days

Consumption during lead time.

= Lead time × Daily usage

= 10 × 75 = 750 units.

Safety stock = 450 units.

Reorder point = Consumption during lead time + Safety stock lead time

= 750 + 450

= 1200 units.

Maximum inventory level = Reorder Quantity + Safety stock

= 4,000 + 450 = 4450 units.

Minimum inventory level = Safety stock = 450 units.

$$\text{Average inventory level} = \frac{\text{Minimum inventory level + Maximum inventory level}}{2}$$

$$= \frac{450 + 4450}{2} = \frac{4900}{2} = 2450 \text{ units.}$$

7. A company requires 1100 units of raw material per month. Price of the raw material is Rs. 15 per unit ordering cost is Rs. 50 per order. Storage cost is 10% per year of the average inventory.

Find the EOQ.

Find the total inventory cost including material cost.

Sol :

$$EOQ = \sqrt{\frac{2C_0}{1}} = \sqrt{\frac{2\times1100\times50}{115\times\frac{10}{100}}}$$

$$= \sqrt{\frac{1,10,000}{1.5}}$$

$$= \sqrt{73333}$$

EOQ = 271 (Approx.)

8. A company buys 2500 units of an item per annum. The annual inventory carrying cost is estimated at 20% and the ordering cost at Rs. 100 per order. The price quoted by the supplier is Rs. 10 per unit subject to discounts at 5% for order of 1000 to 1999, and 7% for orders of 2000 or more, Is it worthwhile increasing the order size to avail the discount offer ?

Sol :

$$EOQ = \sqrt{\frac{2AS}{I}}$$

A = Annual consumption = 2500

S = Cost for placing an orders = 100/-

I = Inventory Carrying cost

10 × 20% = 2_{Rs}

$$EOQ = \sqrt{\frac{2x2500x100}{2}} = 500units$$

(ii) If the supplier offer Discount for higher order quantities the optional order quantity may be arrived at as follows.

at 1,000 units@ 5% Discount

Purchase cost per unit	=	10
Less : Discount		
[10x5%]	=	0.5
Cost PU	=	9.5

at 2000 units @ 7% Discount

Purchase cost per unit = 10

Less: Discount

[10 × 7%] = 0.70

Cost PU = 9.30

	500 Units per Order	1000 Units per Order	2000 Units per Order
Material Purchasing Cost Annual Consumption x Purchasing cost per units	(2500x10)=25,000	(2500x9.5)=23,750	(2500x9.30)=23,250
$\left(\frac{\text{Annual Demand}}{\text{rdering Quanity}} \text{x cost per order}\right)$	$\left(\frac{2500}{500} x100\right) = 500$	$\left(\frac{2500}{1000} x100\right) = 250$	$\left(\frac{2500}{2000} x100\right) = 125$
Add:- Inventory Carrying cost (½ X ordering quantity x cost PU x Carrying cost)	(½x500x10x20%)=200	(½x1000x9.5x20%)=950	(½x2000x9.x20%)=1860
Total Cost →	26,000	24,950	25,235
Since the total cost is minimized when the ordering quantity of 1000 units per order it is advised that to purchase 1000 units per order at discount of 5%			

PROBLEMS ON ABC ANALYSIS

9. From the following data draw an ABC analysis graph after clasifying A, B & C class items.

Item	Unit price	Annual Consumption (units)
1	200.0	3,000
2	2.0	60,000
3	5000.0	20
4	12.5	200
5	9.0	350
6	25.0	6,000
7	1000.0	40
8	70.0	300

Sol :

Step No. 1 : Determination of annual consumption value.

Item	(Annual consumption (units) × Unit price (Rs.)]	Annual consumption value (Rs.) (ACV)
1	3000 × 200	6,00,000
2	60,000 × 2	1,20,000
3	20 × 5000	1,00,000
4	12.5 × 200	2,500
5	9 × 350	3,150
6	25 × 6000	1,50,000
7	1000 × 40	40,000
8	70 × 300	21,000

Step No. 2

Re-arrange the item in the descending order of annual consumption value and calculate cumulative ACV.

Item	(Annual consumption (units) × Unit price (Rs.)]	Annual consumption value (Rs.) (ACV)
1	6,00,000	6,00,000
6	1,50,000	7,50,000
2	1,20,000	8,70,000
3	1,00,000	9,70,000
7	40,000	10,10,000
8	21,000	10,31,000
5	3150	10,34,150
4	2500	10,36,650
	10,36,650	

Step No. 3

Since the basis for ABC classification is not given in the problem, assume the following basis.

Category	Percentage of total ACV
A	70
B	20
C	10

70% of total ACV = 0.70 × 10,36,650 = 7,25,655

Since this value is near to cumulative ACV of Rs. 7,50,000, categorize items 1 and 6 under 'A' category.

(A + B) together account for 90% of ACV.

90% ACV = 0.9 × 10,36,650 = Rs. 9,32,985

since this value is nearer to cumulative ACV of Rs. 9,70,000 categorize items 2 and 3 under 'B' category. The remaining items, 7, 8, 5 and 4 are categorized under 'C' category.

Step 4

Construction of ABC analysis graph

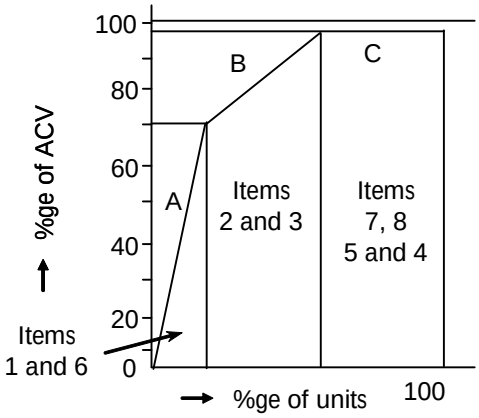
$$\left.\begin{matrix}\text{Exact \% age of ACV of} \\ \text{'A' category items}\end{matrix}\right\} = \frac{7,50,000}{10,36,650} \times 100 = 72.34\%$$

$$\text{Exact \% age of (A + B) items} = \frac{9,70,000}{10,36,650} \times 100 = 93.57\%$$

Exact % age of (A + B) items = $\frac{9,70,000}{10,36,650} \times 100 = 93.57\%$

% age of ACV of 'B' item = 93.57 – 72.34 = 21.23%

% age of ACV of 'C' item = 100 – 93.57 = 6.43%



10. The following data is available on consumption pattern of certain materials in an organisation.

Group	No. of Items	Monthly consumption (units)	Price Item (Rs.)
I	40	3000	9
II	20	270	100
III	100	1700	5
IV	200	1500	4
V	60	340	50
VI	300	2500	1
VII	250	2000	2
VIII	30	170	500

Find out A, B, C items when

'A' item account for 85% of consumption value.

'B' item account for 10% of consumption value.

'C' item account for 5% of consumption value.

Sol :

Step No. 1

Calculation of Monthly Consumption Value (MCV)

Group	No. of Items per group	Monthly consumtion (units)	Unit price (Rs.)	Monthly consumption value (MCV)
I	40	300	90	10,80,000
II	200	270	100	5,40,000
III	100	1700	5	8,50,000
IV	200	1500	4	12,00,000
V	60	340	50	10,20,000
VI	300	2500	1	7,50,000
VII	250	2000	2	10,00,000
VIII	30	170	500	25,50,000
			Total	89,90,000

Step No. 2

Rearrange the groups in the decrasing order of MCV and calculate cumulative MCV for each group.

Group	MCV in descending order (Rs.)	Cumulative MCV (Rs.)
VIII	25,50,000	25,50,000
IV	12,00,000	37,50,000
I	10,80,000	48,30,000
V	10,20,000	58,50,000
VII	10,00,000	68,50,000
III	8,50,000	77,00,000
VI	7,50,000	84,50,000 B
II	5,40,000	89,90,000 C

Step No. 3

Classifying the group as A, B & C based on MCV

85% of total MCV = 0.85 × 89,90,000 = 76,41,500

Since this value is nearer to cumulative MCV of 77,00,000 the groups VIII, IV, V, VII and III are categorized under group 'A'

(A + B) Comprise 95% of MCV

95% of MCV = 0.95 × 89,90,000 = Rs. 85,40,500

Since this value is nearer to 84,50,000 groups VI is under category 'B' and group II is under category 'C'.

11. A company uses 12 different items in the manufacturing process. Their annual requirement and unit costs are given as follows,

Items	Quantity	Unit Cost
1	9,000	10
2	300	750
3	5,400	210
4	3,800	90
5	12,400	10
6	90	1,200
7	600	400
8	22,000	2
9	750	175
10	1,000	250
11	7,600	75
12	10,000	4

Apply ABC analysis and give a graphical presentation.

Sol :

Step 1

Calculation of annual consumption value of given items in rupees.

Items Quantity	Annual demanded	unit Total Cost (f) Consumption	Cost or Annual Value
1	9,000	10	90,000
2	300	750	2,25,000
3	5,400	210	11,34,000
4	3,800	90	3,42,000
5	12,400	10	1,24,000
6	90	1,200	1,08,000
7	600	400	2,40,000
8	22,000	2	44,000
9	750	175	1,31,250
10	1,000	250	2,50,000
11	7,600	75	5,70,000
12	10,000	4	40,000

Step 2

Rearrange the items in the descending order of Annual Consumption Value (ACV) and calculate cumulative value of ACV

Table 2

Item No.	Annual Consumption Value (ACV) in Descending Order (Rs.)	Cumulative Value of ACV (`)
3	11,34,000	11,34,000
11	5,70,000	17,04,000
4	3,42,000	20,46,000
10	2,50,000	22,96,000
7	2,40,000	25,36,000
2	2,25,000	27,61,000
9	1,31,250	28,92,250
5	1,24,000	30,16,250
6	1,08,000	31,24,250
1	90,000	32,14,250
8	44,000	32,58,250
12	40,000	32,98,250
Total	**32,98,250**	

Step 3

Since the basis for ABC classification is not given in the problem assume the following basis.

Table 3

Category	Percentage of total ACV
A	70%
B	20%
C	10%

i.e., 70% of total ACV is consumed by category 'A' items, 20% of ACV is consumed by category 'B' items and 'C' category items constitute 10% of the total ACV.

For category A,

70% of total ACV = 70% of `. 32,98,250

$$= \frac{70}{100} \times 32,98,250$$

= `. 23,08,775.

Since this value is nearer to cumulative ACV of `. 25,36,000. Thus, the items 3, 11,4, 10 and 7 fall under the category 'A'.

Category (A+B) together accounts for 90% of ACV

$$= 90\% \text{ of } `. 32,98,250$$

$$= \frac{90}{100} \times 32,98,250 = `. 29,68,425$$

Since, this value is nearer to cumulative value of ACV of 30,16, 250, therefore categorized item 2, 9 and 5 come under the category 'B'.

The remaining items 6, 1, 8 and 12 are finally categorized under 'C' category.

Step 4

Construction of ABC analysis graph

Exact percentage of ACV of 'A' Category items

$$= \frac{25,36,000}{32,98,250} \times 100 = 76.89\%.$$

Percentage of (A+B) items

$$= \frac{30,16,250}{32,98,250} \times 100 = 91.45\%.$$

Expected percentage of ACV of 'B' category items

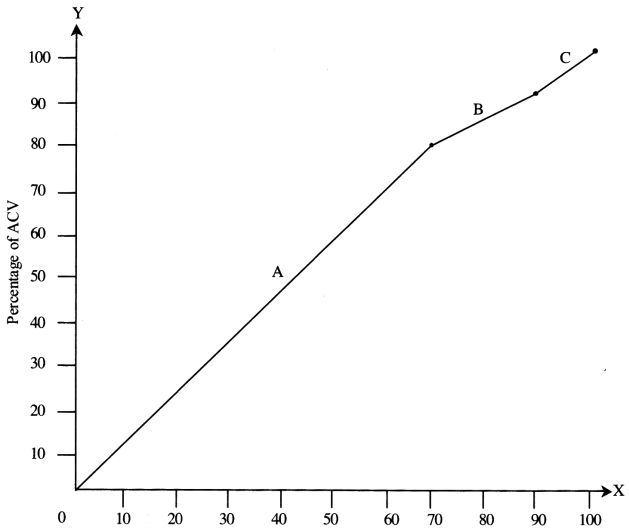
$$= (A+B)\% - A\%$$

$$= 91.45 - 76.89$$

$$= 14.56\%.$$

Expected percentage of ACV of 'C' category items

$$= 100 - 91.45 = 8.55\%.$$



Exercise Problems

1. A factory uses annually 24,000 units of raw-material which costs ` 125 per unit placing each order costs ` 25 and carrying cost is 6% per year of the average inventory.

   (i) Find out the economic order quantity.

   (ii) How many orders are to be placed in a year?

   (iii) What is the total inventory cost for the year including the cost of material.

   [Ans: (i) 400 units, (ii) 60 orders, (iii) 30,03,000].

2. A factory uses annually 24000 units of raw materials which costs ` 1.25 per unit. Placing each order costs ` 25/- and carrying cost is 6% per year of the average inventory.

   (i) Find the EOQ and the total inventory cost including the cost of material.

   (ii) The factory works for 320 days a year. If the procurement time is 10 days and safety stock is 450 units, find the re-order point. The minimum, maximum and average inventories.

   [Ans: (i) 4000 units and 30,300 units, (ii) Re-order point = 1200 units, Max. Inventory = 4,450 units, Min. Inventory = 450 units, Average Inventory = 2,450 units].

3. Classify the following 14 items in ABC categories,

Item no.	Monthly consumption (`)
D-100	451
D-101	1052
D-102	205
D-103	893
D-104	843
D-105	727
D-106	412
D-107	214
D-108	188
D-109	172
D-110	170
D-111	5056
D-112	159
D-113	3424

[Ans: A:70%, B:20% and C:10%].

4. The stores of a repair shop has 10 items whose details are shown in the following table. Apply ABC analysis to the stores and identify A class, B class, C class items.

Details of Store

Component code	Price/unit (`)	Units/year
C01	110	125
C02	3000	40
C03	225	310
C04	60	720
C05	310	425
C06	700	525
C07	500	900
C08	1000	90
C09	7000	510
C10	800	600

[Ans : A= C06, B= C09, C10, C = C01, C02, C03, C04, C05, C07, C08].

Short Question and Answers

1. Define the term inventory.

Ans :

Inventory is simply a stock of physical assets having economic value, which can be either in the form of material, money or labour. Inventory is also known as an idle resource as long as it is not utilized. Inventory may be regarded as those goods which are procured, stored and used for day to day functioning of the organisation. This can be in the form of physical resource such as raw materials, semi-finished goods used in the production process, finished products ready for delivery to consumers; human resources such as unutilized labour, or financial resource such as working capital etc.

The decisions which are directly related with the management of firm's inventory (stock) are referred as inventory decisions. These decisions helps the firm to maintain efficient balance between three types of costs such as.

a) Inventory shortage costs

b) Inventory holding costs

c) Inventory ordering costs.

2. Define safety stock.

Ans :

The safety stock is defined as the minimum additional inventory to serve as a safety margin or cushion to meet an unanticipated increase in usage resulting from various uncontrollable factors.

In real life situations, firms operate under conditions of uncertainty relative both the demand as well as procurement time. Total actual demand may be more or less than the forecasted demand. Similarly, actual procurement time may vary from the estimated time. In order to minimize effect of uncertainty in demand and/or lead time a firm maintains safety stock.

Thus, safety stock is held for the following reasons,

(a) Any excessive in-process rejection

(b) Rejections at the time of receipts

(c) Unexpected delay in delivery of goods

(d) Fluctuations in demand.

3. Store management

Ans :

Store is a building where goods are kept, stores is defined as supplies of goods. Storage is defined as the act of storing the goods.

Stores or storage is the function of receiving, storing and issuing materials. It involves the supervision of raw materials, maintaining the goods in good condition, and providing for production when ever required.

4. Objectives of Store Management

Ans :

The various objectives of stores management are as follows,

i) To protect the goods available in storage against the losses, in order to verify that the value of this credit is recorded accurately in the book.

ii) To make the goods available for on time delivery.

iii) To provide low cost services of store keeping to the sales and manufacturing department.

iv) To eliminate the storage of raw materials.

v) To ensure that the facilities of storage are located near the operating department.

vi) To maintain the required material in adequate quantities.

vii) To ensure that materials are not available in excess quantities than required.

viii) To buy the materials as per the principle of economic order quantity as it helps in minimizing the associated costs.

ix) To ensure that the stores are maintained in clean and good condition.

x) To ensure that unauthorized persons do not enter the stores.

5. Objectives of Material Control

Ans :

The following are the objectives of material control,

i) To ensure continuous supply of materials.

ii) To avoid making excessive investment in materials.

iii) To reduce the wastage of materials.

iv) To follow an effective issue method of materials for reducing the risk of spoilage and obsolescence.

v) To maintain accurate information about the availability of materials.

vi) To avoid misappropriation of materials.

vii) Tomainta' eliability in the payment of amount to suppliers.

6. Codification

Ans :

It is one of the functions of stores management. Codification is a process of representing each item by a number, the digit of which indicates the group, the sub-group, the type and the dimension of the item. Many organizations in the public and private sectors, railways have their own system of codification, varying from eight to thirteen digits. The first two digits represents the major groups, such as raw materials, spare parts, sub-contracted items, hardware items, packing material, tools, oil, stationery etc. The next two digits indicate the sub-groups, such as, ferrous, non-ferrous etc. Dimensional characteristics of length, width, head diameter etc. constitute further three digits and the last digit is reserved for minor variations.

7. Standardization

Ans :

Standardization is a procedure in which rules are developed and used for a systematic approach to a specific activity with cooperation of all related parties in order to benefit and enhance the optimum overall economy by considering functional conditions and safety requirements. Standardization depends on the combined results of science, techniques and experience. It is not only emphasizing on the present but also focuses on future development'.

8. Advantages of Standardization

Ans :

- Fewer specifications, drawings and part lists have to be prepared and issued.
- Better quality products.
- Lower unit costs.
- Increased margin of profit.
- Easy availability of spares.
- Minimum inventory cost.
- Quantity discounts are possible because of purchase of raw materials in large volume.

9. Define Simplication

Ans :

Simplification is the first step of standardization. It is the process which deals with minimizing different types of manufactured products. It helps in minimizing product range, assemblies, parts, materials and design.

Simplification is beneficial to manufacturers, suppliers and buyers. It carries out the advantages of reduced inventory, better plant utilization, greater use of storage space and reduction of buying/selling efforts to manufacturers. It makes suppliers to focus on the sale of fewer items. Thus, they can maximise their turnover. Finally buyers can experience better after sales service with this process of simplification followed by the manufacturers.

Simplification means elimination of superfluous varieties, sizes, dimensions, etc. Product simplification means reducing the number of varieties. The other names for simplification are unification or variety reduction.

Simplification will be advantageous to manufacturers, suppliers and buyers. Reduced inventory, better plant utilization, greater use of storage space, reduction of buying/selling efforts are

the advantages to manufacturers. Suppliers can concentrate on the sale of fewer items and thereby increase their turnover. Buyers can have better after sales services due to the use of less number of parts. Simplification is the first step towards standardization.

10. Bin Card

Ans :

Bin is a place where materials are kept in. It may be a rack, container, shelf or space where stores are kept. Bin card is a document showing the particulars of materials kept in the bin. It is a document attached to the bin disclosing the quantitative details of materials received, issued and the closing balance. A bin card is used for each item of material. Each receipt and issue is recorded on the bin card in a chronological order and the latest balance is shown after each receipt and issue. Bin card is maintained by the store keeper. It indicates information like different stock levels. No, name of material, material code number, stores ledger folio number, quantity of materials received, issued and the balance in hand.

11. Two Bin System

Ans :

Two bin system is used for the material control. It is that technique of material control in which we have two bins, one is used for in use minimum stock and second bin is used for reserve stock or to keep the remaining quantity of material. This system of inventory control is also called in USA kanban. First bin is utilized for issuing the material for production and then, second bin is used. Its record is done on bin cards and store ledger card.

Two bin systems are common on assembly and moving manufacturing lines where components are added to the product or item being built. The two bin system is just like its name suggests, it is composed of two bins which are full of components or materials to start. As production commences one bin is drawn down of materials and the other bin, which is still full, acts as the buffer or safety stock.

When the first bin is completely depleted the worker or assembly line worker switches to the other bin, similar to a FIFO system. The switch of bins can be interpreted as a kanban signal for the supply process of that particular component to manufacture or supply the component just in time before the second bin runs out of material. The kanban signal can also be generated half way throughout the first bin, depending on lead times for the component to be supplied.

This system in a way is similar to the EOQ inventory model with safety stock. It is a very common system used in vehicle manufacturing plants. The size or number of components in each bin is usually determined using the EOQ inventory model or a time period model.

12. Store Ledger

Ans :

Store ledger is a document showing the quantity and value of materials received, issued and in balance at the end. One stores ledger is allotted to each component of material. Entries are made in this ledger by the costing clerk with reference to goods received note, material requisition note, material returned note etc. It is very similar to the bin card except it contains additional columns showing the prices and value of materials received, issued and balance in hand. It gives the value of closing stock at any time. Besides, a store ledger contain information like name of the material, code number, different stock levels etc.

13. Difference between Store Ledger and Bin Card.

Ans :

Soter Ledger	Bin Card
1. It is a record of both quantity and value.	1. It is a record of quantity onty.
2. It is maintained by the cost clerk.	2. It is maintained by the storekeeper.
3. It is kept in the cost office.	3. It is attached to the bin.
4. Entiles are made by the cost clerk.	4. Entries are mode by Ibe store keeper.
5. Entries are made on the basis of documents like goods received note, material requisition note etc.	5. Entries are made on the basis of actual quantity received and issued.
6. Posting are made after the transactions.	6. Postings are made before the transactions.
7. Transactions are periodically recorded.	7. Individual transactions are recorded.
8. Inter departmental transactions are recorded for costing purpose.	8. Inter departmental transfers aie not shown.
9. Facilitates physical verification of closing stock.	9. Facilitates physical verification of closing stock

14. ABC Analysis

Ans :

ABC analysis underlines a very important principle "Vital few : trivial many". Statistics reveal that just a handful of items account for bulk of the annual expenditure on materials. These few items, called 'A' items, therefore hold the key to business. The other items, known as 'B' and 'C' items, are numerous in number but their contribution is less significant. ABC analysis thus tends to segregate all items into three categories : A, B and C on the basis of their annual usage. The categorisation so made enables one to pay the right amount of attention as merited by the items.

A-Items : It is usually found that hardly 5-10% of the total items account for 70-75% of the total money spent on the materials. These items require detailed and rigid control and need to be stocked in smaller quantities. These items should be procured frequently, the quantity per occasion being small. A healthy approach, however, would be to enter into contract with the manufacturers of these items and have their supply in staggered lots according to production programme of the buyer. This, however, will be possible when the demand is steady. Alternatively, the inventory can be kept at minimum by frequent ordering.

B-Items : These items are generally 10-15% of the total items and represent 10-15% of the total expenditure on the materials. These arc intermediate items. The control on these items need not be as detailed and as rigid as applied to C items.

C-Items : These are numerous (as many as 70-80% of the total items), inexpensive (represent hardly 5-10% of the total annual expenditure on materials) and hence insignificant (do not require close control) items. The procurement policy for these items is exactly the reverse of A items. C items should be procured infrequently and in sufficient quantities. This enables the buyer to avail price discounts and reduce work load of the concerned departments.

15. HML Analysis

Ans :

H-M-L analysis is similar to ABC analysis except for the difference that instead of "usage value", "price" criterion is used. The items under this analysis are classified into three groups which are called "High", "Medium" and "Low". To classify, the items are listed in the descending order of their unit price. The cut-off-lines are then fixed by the management for deciding three categories. For example, the management may decide that all items of unit price above Rs. 1000 will be of 'H' category, those with unit price between Rs. 100 to Rs. 1000 will be of 'M' category and those having unit price below Rs. 100 will be of 'L' category.

HML analysis helps to

- Assess storage and security requirements (e.g. high priced items like bearings, worm shafts, worm wheels, etc. require to be kept in the cupboards).
- To keep control over consumption at the departmental head level (e.g. indents of high and medium priced items are authorised by the departmental head after careful scrutiny of the consumption figures).
- Determine the frequency of stock verification, e.g. high priced items are checked more frequently than low priced items.
- To evolve buying policies to control purchases e.g. excess supply than the order quantity may not be accepted for "H" and "M" groups while it may be accepted for "L" group.
- To delegate authorities to different buyers to make petty cash purchase e.g. "H" and "M" catagory of items may be purchased by senior buyers and "L" category of items by junior buyers.

16. VED Analysis

Ans :

VED analysis represents classification of items based on their criticality. The analysis classifies the items into three groups called Vital, Essential and Desirable. "Vital" category encompasses those items for want of which production would come to halt. "Essential" group includes items whose stockouts cost is very high. And "Desirable" group comprises of items which do not cause any immediate loss of production or their stockout entail nominal expenditure and cause minor disruptions for a short duration.

VED (Vital - Essential - Desirable) analysis is carried out to identify critical items. An item which usagewise belongs to C-category may be critical from production point of view if its stockout can cause heavy production loss.

An item may be vital for a number of reasons, namely.

- If the non-availability of the item can cause serious production losses.
- Lead time for procurement is very large.
- It is non-standard item and is procured to buyer's design.
- The sources of supply is only one and is located far off from the buyer's plant.

17. S-D-E Analysis

Ans :

S-D-E analysis is based on the problems of procurement namely :

- non-availability
- scarcity
- longer lead time
- geographical location of suppliers, and
- reliability of suppliers, etc.

S-D-E analysis classifies the items into three groups called "Scarce", "Difficult" and "Easy". The information so developed is then used to decide purchasing strategies.

"Scare" classification comprises of items which are in short supply, imported or cannalised through government agencies. Such items arc best to procure limited number of times a year in lieu of effort and expenditure involved in the procedure for import.

"Difficult" classification includes those items which are available indigeneously but are not easy to procure. Also items which come from long distance and for which reliable sources do not exist

fall into this category. Even the items which are difficult to manufacture and only one or two manufacturers are available belong to this group. Suppliers of such items require several weeks of advance notice.

"Easy" classification covers those items which are readily available. Items produced to commercial standards, items where supply exceeds demand and others which are locally available fall into this group.

18. S-OS Analysis

Ans :

S-OS analysis is based on seasonality of the items and it classifies the items into two groups S (seasonal) and OS (i.e. Off Seasonal). The analysis identifies items which are :

(i) Seasonal and are available only for a limited period. For example agriculture produce like raw mangoes, raw materials for cigarette and paper industries, etc. are available for a limited time and therefore such items are procured to last the full year.

(ii) Seasonal but are available throughout the year. Their prices, however, are lower during the harvest time. The quantity of such items requires to be fixed after comparing the cost savings due to lower prices if purchased during season against higher cost of carrying inventories if purchased throughout the year.

(iii) Non-scasonal items whose quantity is decided on different considerations.

19. M-N-G Analysis

Ans :

M-N-G analysis based on stock turn over rate and it classifies the items into M (Moving items), N (Non-moving items) and G (Ghost items.)

M (moving items) are those items which are consumed from time to time. N (Non-moving items) are those which arc not consumed in the last one year. G (Ghost items) are those items which had nil balance, both in the begining and at the end of the last financial year and there were no transactions (receipt or issues) during the year.

Analysis mainly helps to identify non-existing items for which the store keeps bin-cards or waste computer memory or waste computer stationary while preparing stores ledger. Stores department even might have even car-marked space for these non-existent items.

All pending / open purchase orders (if any) of such items should be cancelled.

20. F-S-N Analysis

Ans :

F-S-N analysis is based on the consumption figures of the items. The items under this analysis are classified into three groups : F (fast moving), S (low moving) and N (non-moving)

To conduct the analysis, the last date of receipt or the last date of issue whichever is later is taken into account and the period, usually in terms of number of months, that has elapsed since the last movement is recorded.

Such an analysis helps to identify :

(i) Active items which require to be reviewed regularly.

(ii) Surplus items whose stocks are higher than their rale of consumption; and

(iii) Non-moving items which arc not being consumed. The last two categories are reviewed further to decide on disposal action to deplete their stocks and thereby release company's productive capital.

Further detailed analysis is made of the third category in regards to their year-wise stocks and items can be sub-classified as non-moving for 2 years, non-moving for 3 years, non-moving for 5 years and so on.

Choose the Correct Answers

1. Fixed order period sy stem is also to _____ as. [b]
   (a) Q-system (b) P-system
   (c) Hybrid-system (d) One-bin system.
2. Safety stock is calculated by using which of the following formula? [a]
   (a) Safety Stock = (Maximum Lead Time - Normal Lead Time) × Monthly Consumption
   (b) Safety Stock = (Minimum Lead Time - Normal Lead Time) × Monthly Consumption
   (c) Safety Stock = (Maximum Lead Time - Normal Lead Time) × Annual Consumption
   (d) Safety Stock = (Maximum Stock Level - Minimum Stock Level) × Per Day Consumption
3. _____ is the process which deals with minimizing different types of manufactured products. [c]
   (a) Classification (b) Codification
   (c) Simplification (d) Standardization.
4. In VED analysis, inventory items are categorized on the basic of what? [d]
   (a) Unit cost (b) Consumption rate
   (c) Annual consumption value (d) Criticality of the items.
5. In analysis, the inventory items are categorized on the basis of consumption. [d]
   (a) ABC analysis (b) XYZ analysis
   (c) SDE analysis (d) FNSD analysis.
6. _____ analysis approach is usually applied for categorizing the spare parts. [b]
   (a) XYZ analysis (b) VED analysis
   (c) FSND analysis (d) SED analysis
7. In operations management, classification of materials are categorized into . [a]
   (a) ABC analysis and VED analysis (b) VED analysis and FSND analysis
   (c) SDE analysis and XYZ analysis (d) None of the above.
8. The deterministic models of inventory are _____ . [c]
   (a) Purchase models with and without shortages
   (b) Manufacturing models with and without shortages
   (c) Both (a) and (b)
   (d) None of the above
9. The techniques for stores management includes [d]
   (a) Receiving and checking (b) Issue and dispatch
   (c) Stock records (d) All the above.
10. Probabilistic models of inventory consists of _____. [d]
    (a) Fixed order quantity system (b) Fixed period quantity system
    (c) Hybrid system (d) Only (a) and (b)

Fill in the blanks

1 _____ is a place where inventory items or materials are preserved.

2. The procedure followed for categorizing the items in XYZ analysis is same as analysis.

3. The fixed order quantity in Q-system is regarded as _____.

4. Safety stock is also known as _____.

5. The record maintained for showing quantitative receipts and issue of materials is called as _____.

6. Fixed order quantity system is also known as _____.

7. ABC analysis was developed on the basis of the _____.

8. In ABC analysis, ABC stands for _____.

9. _____ is the process of allotting a code system symbol or a code number to a particular item.

10. Under Q-System, the period of order varies depending upon the _____.

ANSWERS

1. Store
2. ABC Analysis
3. Economic Order Quantity (EOQ)
4. Buffer Stock
5. Bin Card
6. Q-System
7. Pareto's principle
8. Always Better Control
9. Codification
10. Demand

FACULTY OF MANAGEMENT

M.B.A (CBCS) III- Semester Examination

MODEL PAPER - I

OPERATIONS MANAGEMENT

Time : 3 Hours] **[Max. Marks : 80**

Note : Answer all the questions from Part - A and Part - B

Each question carries 4 marks in Part - A and 12 marks in Part - B

SECTION - A - (5 × 4 = 20 Marks)

[Short Answer Type]

ANSWERS

1. Batch Process **(Unit-I, SQA.8)**
2. Define aggregate planning **(Unit-II, SQA.8)**
3. Time Study **(Unit-III, SQA.5)**
4. Material Requirement Planning **(Unit-IV, SQA.3)**
5. Two Bin System **(Unit-V, SQA.11)**

SECTION - B - (5 × 12 = 60 Marks)

[Essay Answer Type]

6. (a) What are the major factors effecting process design decisions. **(Unit-I, Q.No.26)**

(OR)

(b) Explain the various stages of process life cycle. **(Unit-I, Q.No.33)**

7. (a) In a both production five jobs A, B, C, D and E are required to be processed on three machines as detailed below. What is the optimum sequence and elapsed time ?

Process, Time on Machine	Jobs				
	A	B	C	D	E
Cleaning	7	6	8	9	10
Machinery	1	4	5	2	3
Painting	3	2	4	5	7

(Unit-II, Prob.10)

(OR)

(b) Define maintenance management. State the objectives of maintenance management. **(Unit-II, Q.No.42)**

8. (a) Write about scheduling customer as product service operation **(Unit-III, Q.No.16)**

(OR)

(b) Define work study. What are the various components of work study ? **(Unit-III, Q.No.1)**

9. (a) Write about manufacturing resources planning. **(Unit-IV, Q.No.6)**

(OR)

(b) Define vendor rating? What are the factors determining vendor rating? **(Unit-IV, Q.No.15)**

10. (a) Explain various probabilistic models of inventory. **(Unit-V, Q.No.11)**

(OR)

(b) Define store management. What are the objectives of store management. **(Unit-V, Q.No.14)**

FACULTY OF MANAGEMENT

M.B.A (CBCS) III- Semester Examination

MODEL PAPER - II

OPERATIONS MANAGEMENT

Time : 3 Hours] **[Max. Marks : 80**

Note : Answer all the questions from Part - A and Part - B

Each question carries 4 marks in Part - A and 12 marks in Part - B

SECTION - A - (5 × 4 = 20 Marks)

[Short Answer Type]

ANSWERS

1. Objectives of Operations Management. **(Unit-I, SQA.2)**
2. Master production scheduling. **(Unit-II, SQA.10)**
3. Define work study. **(Unit-III, SQA.1)**
4. Purchase management. **(Unit-IV, SQA.5)**
5. Objectives of Store Management. **(Unit-V, SQA.4)**

SECTION - B - (5 × 12 = 60 Marks)

[Essay Answer Type]

6. (a) What are the functions of PPC ? **(Unit-I, Q.No.30)**

(OR)

(b) What is process design ? and discuss the various types of process design. **(Unit-I, Q.No.25)**

7. (a) What are the factors affecting the plant layout. **(Unit-II, Q.No.16)**

(OR)

(b) Explain various mathematical model for aggregate planning. **(Unit-II, Q.No.30)**

8. (a) What are the techniques of method study? **(Unit-III, Q.No.7)**

(OR)

(b) Define service quality ? What are the dimensions of service quality ? **(Unit-III, Q.No.19)**

9. (a) Explain the need and importance of materials management. **(Unit-IV, Q.No.3)**

(OR)

(b) Explain the role of value analysis in cost reduction. **(Unit-IV, Q.No.21)**

10. (a) What are the various functions of inventory? **(Unit-V, Q.No.3)**

(OR)

(b) Explain about Bin Card, Double Bin and Stores Leader. **(Unit-V, Q.No.23)**

FACULTY OF MANAGEMENT

M.B.A (CBCS) III- Semester Examination

MODEL PAPER - III

OPERATIONS MANAGEMENT

Time : 3 Hours] **[Max. Marks : 80**

Note : Answer all the questions from Part - A and Part - B

Each question carries 4 marks in Part - A and 12 marks in Part - B

SECTION - A - (5 × 4 = 20 Marks)

[Short Answer Type]

ANSWERS

1. Shearing extrusion. **(Unit-I, SQA.4)**
2. Objectives of Plant Layout. **(Unit-II, SQA.6)**
3. Define work measurement. **(Unit-III, SQA.4)**
4. Significance of Materials Management **(Unit-IV, SQA.2)**
5. Define the term inventory. **(Unit-V, SQA.1)**

SECTION - B - (5 × 12 = 60 Marks)

[Essay Answer Type]

6. (a) Explain the various stages of process life cycle. **(Unit-I, Q.No.33)**

(OR)

(b) Define PPC. What are the objectives of PPC? **(Unit-I, Q.No.27)**

7. (a) Design an assembly line for a cycle time of 10 min. for the following work elements.

Elements	1	2	3	4	5	6	7	8	9	10
Immediate Precedessors	-	1	1	2, 3	4	4	6	5	7, 8	9
Duration in Minutes	5	10	5	2	7	5	10	2	5	7

Calculation the line efficiency for the balanced line. **(Unit-II, Prob.4)**

(OR)

(b) What are the objectives master production scheduling? **(Unit-II, Q.No.32)**

8. (a) Define work study. What are the various components of work study? **(Unit-III, Q.No.1)**

(OR)

(b) Define service culture. Explain the element of Service Culture. **(Unit-III, Q.No.21)**

9. (a) What is material requirement planning (MRP)? Explain the objective of MRP. **(Unit-IV, Q.No.4)**

(OR)

(b) Explain the role of value analysis in cost reduction. **(Unit-IV, Q.No.21)**

10. (a) What are the various functions of inventory? **(Unit-V, Q.No.3)**

(OR)

(b) The following data is available on consumption pattern of certain materials in an organisation.

Group	No. of Items	Monthly consumption (units)	Price Item (Rs.)
I	40	3000	9
II	20	270	100
III	100	1700	5
IV	200	1500	4
V	60	340	50
VI	300	2500	1
VII	250	2000	2
VIII	30	170	500

Find out A, B, C items when

'A' item account for 85% of consumption value.

'B' item account for 10% of consumption value.

'C' item account for 5% of consumption value. **(Unit-V, Prob.10)**

FACULTY OF MANAGEMENT

M.B.A III-Semester (CBCS) Examination

January - 2018

OPERATIONS MANAGEMENT

Time : 3 Hours] **[Max. Marks : 80**

PART - A (5 × 4 = 20 Marks)
[Short Answer Type]

ANSWERS

1. Shearing Extrusion **(Unit-I, SQA-4)**
2. Preventive and Corrective Maintenance **(Unit-II, Q.No.50)**
3. Service Quality **(Unit-III, Q.No.19)**
4. Vendor Rating **(Unit-IV, Q.No.15)**
5. Selective Inventory Control **(Unit-V, Q.No.25)**

PART - B (5 × 12 = 60 Marks)
[Essay Answer Type]

6. (a) Define production, planning and control. Explain the functions of production planning and control. **(Unit-I, Q.No. 29,30)**

OR

(b) Compare and contrast between products and services. **(Unit-I, Q.No.9)**

7. (a) Five jobs ABCD and E are to be processed through three operations O_1, O_2 and O_3. The processing times in minutes are given below.

	Processing time in minutes Jobs		
Jobs	O_1	O_2	O_3
A	17	15	16
B	18	15	18
C	16	14	17
D	15	12	14
E	16	11	13

Vou are required to give the optimal sequence of the jobs and for that sequence find the,

(i) Total completion time of jobs

(ii) Waiting time of jobs

(iii) Idle time of machines.

Ans :

Step 1

John's Rule (Extension)

Min $O_1 \geq$ Max O_2

15 = 15 (Condition is Satisfied)

Step 2

Create two ficitious operations O_4 and O_5.

$O_4 = O_1 + O_2$

$O_5 = O_2 + O_3$

Jobs	O_4	O_5
A	32	31
B	33	33
C	30	31
D	27	26
E	27	24

Step 3

John's Rule

C	B	A	D	E

Calculation of Times

Jobs	O_1				O_2				O_3			
	In time	Process time	Out time	Idle time	In time	Process time	Out time	Idle time	In time	Process time	Out time	Idle time
C	0	16	16	0	16	14	30	16	30	17	47	30
B	16	18	34	0	34	15	49	4	49	18	67	2
A	34	17	51	0	51	15	66	2	67	16	83	0
D	51	15	66	0	66	12	78	0	83	14	97	0
E	66	16	82	0+28	82	11	93	4+17	97	13	10	0

Total Idle time

Operation 1 = 28

Operation 2 = 43 (21 + 2 + 4 + 16)

Operation 3 = 32 (30 + 2)

Total completion time = 110 Minutes

Waiting time for jobs

C	–	0
B	(49 – 49)	0
A	(66 – 67)	1
D	(78 – 83)	5
E	(93 – 97)	4

OR

(b) In a factory during an eight hours shift the number of units produced are 876 with an idle time of 18%. The performance rating is 125% and an allowance of 14% of normal time is permitted. You are required to find the standard time per unit.

Ans :

i) Observed Time Per Units

= Working time – idle time

= 8 – (18% of 8)

= 8 – (0.18 × 8)

= 8 – (1.44)

= 6.6 hours

= 396 minutes

Observed Time for 876 units = 396 Min

$$= \frac{396}{876} = 0.45 \text{ min}$$

ii) Calculation of Normal Time

$$\text{Normal Time} = \frac{\text{Observed Time} \times \text{Observed Rating}}{\text{Standard Rating}}$$

$$= 0.45 \times \frac{125}{100}$$

= 0.56 minutes

iii) Calculation of Standard Time

Standard Time = Normal Time + Allowance (% of Normal Time)

= 0.56 + (14% of 0.56)

$$= 0.56 + \left(\frac{14}{100} \times 0.56\right)$$

= 0.64 Minutes.

8. (a) Discuss about creation of value through services. **(Unit-III, Q.No.18)**

OR

(b) Define work study. State and explain the methods of work studs. **(Unit-III, Q.No.1,7)**

9. (a) Explain the needs significance of materials requirement planning. **(Unit-IV, Q.No.4)**

OR

(b) Elucidate the role of value analysis in cost reduction. **(Unit-IV, Q.No.21)**

10. (a) Write about scientific methods of stores management. **(Unit-V, Q.No.25)**

OR

(b) The annual requirement of a material in 66000 units. The carrying cost per unit per year is ` 6.56 and cost of placing an order in ` 500. The unit cost is ` 18. Find EOQ. Further the supplier of these material had offered the following discounts. What would be the new EOQ with discounts.

Quality	Discounts
Upto 6000 units	0%
6001 to 12000 units	1%
12001 to 24000 units	2%
24001 to 36000 units	2.5%
Above 36000 units	3%

Ans :

Annual consumption = 66000 units

Cost per until = 18

Order cost = 500

Carrying cost = 6.56

$$EOQ = \sqrt{\frac{2AO}{C}} = \sqrt{\frac{2 \times 66000 \times 500}{6.56}} = 3{,}172 \text{ Units}$$

Calculation of Discounts

No. of Orders	1	2	3	4	5	6	7	8	9	10
Size	66000	33000	22000	16500	13200	11000	9428	8250	7333.33	6600
Average inventory	33000	16500	11000	8250	6600	5500	4714.5	4125	3666.5	3300
Carrying cost	2,16,480	1,08,240	72,160	54,120	43,296	36,080	30,930	27,060	24056	21,648
Order Cost	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4500	5,000
Total Cost	2,16,980	1,09,240	73,660	56,120	45,796	39,080	34,430	31,060	28,556	26,648
(–) Discount	1,980	1,650	1,320	1,320	1,320	660	660	660	660	660
	2,15,000	1,07,590	72,340	54,800	44,476	38,240	33,770	30,400	27,896	25,988

Working Notes

i) $\text{Size} = \frac{66,000}{\text{Number of Orders}}$

ii) $\text{Average Inventory} = \frac{\text{Order Size}}{2}$

iii) Carrying cost = Average inventory × 6.56

iv) Order cost = Cost per order × Number of Orders

FACULTY OF MANAGEMENT

M.B.A III - Semester Examination

May/June - 2018

OPERATIONS MANAGEMENT

Time : 3 Hours] [Max. Marks : 80

PART - A (5 × 4 = 20 Marks)

[Short Answer type]

ANSWERS

1. Types of Manufacturing processes. **(Unit - I, Q.No.10)**
2. Aggregate planning **(Unit - II, SQA-8)**
3. Work Study **(Unit - III, SQA-1)**
4. Value Analysis **(Unit - IV, SQA-8)**
5. Need for Materials Management **(Unit - IV, SQA-3)**

PART - B (5 × 12 = 60 Marks)

[Essay Answer type]

6. (a) Describe and compare the phases in product life cycle and process of life cycle. **(Unit - I, Q.No.34)**

Or

(b) Write about job, batch and mass production systems. **(Unit - I, Q.No.25)**

7. (a) Explain the factors influencing product and process layout. **(Unit - II, Q.No.18,19)**

Or

(b) Five elements of a job are subjected to five cycles. The time recorded in minutes is given below.

Element	Cycles				
	C_1	C_2	C_3	C_4	C_5
A	33	26	30	27	35
B	36	30	28	27	32
C	44	25	32	30	38
D	39	28	24	25	36
E	32	31	29	23	42

You are required to find the normal time and standard time of the job considering 15% of it as allowance.

Sol. :

Normal time = Average cycle time

Element 'A' $= \frac{33 + 26 + 30 + 27 + 35}{5} = \frac{151}{5} = 30.2$

$$\text{Standard time} = \frac{\text{Normal time}}{1 - \text{Allowance time}}$$

Allowance time = 15% of normal time

$= 30.2 \times 15\% = 4.53$

$$= \frac{30.2}{1 - 4.53} = \frac{30.2}{-3.53} = -8.55$$

Element 'B'

$$\text{Normal time} = \frac{36 + 30 + 28 + 27 + 32}{5} = 30.6$$

$$\text{Standard time} = \frac{\text{Normal time}}{1 - \text{Allowance time}}$$

Allowance time = 15% of normal time

$15\% \times 30.6 = 4.59$

$$= \frac{30.6}{1 - 4.59} = \frac{30.6}{-3.59} = -8.52$$

Element 'C'

$$\text{Normal time} = \frac{44 + 25 + 32 + 30 + 38}{5} = 33.8$$

$$\text{Standard time} = \frac{\text{Normal time}}{1 - \text{Allowance time}}$$

Allowance time = 15% of normal time

$15\% \times 33.8 = 5.07$

$$= \frac{33.8}{1 - 5.07} = \frac{33.8}{-4.07} = -8.38$$

Element 'D'

$$\text{Normal time} = \frac{39 + 28 + 24 + 25 + 36}{5} = 30.4$$

$$\text{Standard time} = \frac{\text{Normal time}}{1 - \text{Allowance time}} = \frac{30.4}{1 - 4.56}$$

$$= \frac{30.4}{-3.56} = -8.54$$

Allowance time = 15% of normal time

$15\% \times 30.4 = 4.56$

Element 'E'

Normal time = $\frac{32+31+29+23+42}{5}$ = 31.4

Standard time = $\frac{\text{Normal time}}{1-\text{allowance time}}$

Allowance time = 15% of normal time

15% × 31.4 = 4.71

= $\frac{31.4}{1-4.71}$ = $\frac{31.4}{3.71}$ = – 8.46

8. (a) Describe the procedure of master production scheduling. **(Unit - II, Q.No.33)**

Or

(b) Explain about development of aggregate plans for service organisations. **(Unit - II, Q.No.29)**

9. (a) What are the various techniques used for rating a vendor ? **(Unit - IV, Q.No.16)**

Or

(b) Describe the process of materials requirement planning. **(Unit - IV, Q.No.6)**

10. (a) The annual requirement of a materials is 72000 units. The cost of placing an order in Rs.456 and the carrying cost per unit per annum is Rs.3.45. You are required to find the EOQ and number of orders to be place in a year. Further for a 11% increase or decrease in carrying cost what would be EOQ and number of orders in a year.

Ans :

Annual consumption (A) = 72,000

Cost of placing on order (0) = 456

Carrying cost (C) = 3.45

EOQ = $\sqrt{\frac{2A0}{C}}$

= $\sqrt{\frac{2\times 72000\times 456}{3.45}}$ = $\sqrt{19033043.4}$

4362 (units)

If Carrying cost 11% (Decrease)

= Carrying cost = 3.45

(–) Decrease 11% = 0.38

3.07

$$EOQ = \sqrt{\frac{2AO}{C}} = \sqrt{\frac{2 \times 72000 \times 456}{3.07}}$$

$$= \sqrt{21388925} = 4625$$

$$\text{No. of orders} = \frac{\text{Annual consumption}}{EOQ}$$

$$= \frac{72000}{4625} = 15.56$$

$$\text{No. of orders} = \frac{\text{Annual consumption}}{EOQ}$$

$$= \frac{72000}{4362} = 16.5$$

a) If carrying cost 11% Increase

Carrying cost = 3.45

(+) 11% 0.38

3.83

$$EOQ = \sqrt{\frac{2 \times 72000 \times 456}{3.83}}$$

$$= \sqrt{17144647.5} = 4140$$

$$\text{No. of orders} = \frac{\text{Annual consumption}}{EOQ}$$

$$= \frac{72,000}{4140} = 17.39$$

Or

b) Categories the following materials into A, B and C and give a graphical presentation of the same.

Items	Units	Unit Price (Rs.)
A	9870	23
B	245	45
C	18900	22
D	27400	8
E	9000	46
F	3200	32
G	15400	9
H	650	200
I	9000	111

Sol. :

Items	(Units × Unit price)	Annual consumption value
A	9870 × 23	2,24,710
B	245 × 45	11,025
C	18,900 × 22	4,15,800
D	27,400 × 8	2,19,200
E	9000 × 46	4,14,000
F	3200 × 32	1,02,400
G	15,400 × 9	1,38,600
H	650 × 200	1,30,000
I	9,000 × 111	9,99,000

Step 2 : Re-arrange the item in the descending orders of units.

Item	ACV	Cumulative ACV	
I	9,99,000	9,99,000	
C	4,15,800	14,14,800	'A' Category
E	4,14,000	18,28,800	
A	2,24,710	20,53,510	'B' Cateogry
D	2,19,200	22,27,710	
G	1,38,600	24,11,310	
H	1,30,000	25,41,310	'C' Category
F	1,02,400	26,43,710	
B	11,025	26,54,735	

Since ABC classification is not given in the problem assume the following basis.

A	70
B	20
C	10

"A" category

70% of ACV = 0.70 × 26,54,735

= 18,58,314.50

(A + B) together account for 90% of ACV.

"B" category 90% ACV = 0.9 × 26,54,735

= 23,89,261.50

∴ Item G, H, F, B comes under 'C' category.

FACULTY OF MANAGEMENT

M.B.A III-Semester (CBCS) Examination

December - 2018

OPERATIONS MANAGEMENT

Time : 3 Hours] **[Max. Marks : 80**

PART - A (5 × 4 = 20 Marks)
[Short Answer Type]

Note: Answer all the questions in not more than one page each

ANSWERS

1. Operations strategy **(Unit-I, Q.No.23)**
2. Service facility layout **(Unit-II, SQA-7)**
3. Service management **(Unit-III, SQA-8)**
4. Bin Card, Double Bin and Stores Ledger. **(Unit-V, SQA-10, 11,12)**
5. Classification, codification, simplification and standardization of materials. **(Unit-V, Q.No.19,SQA-6,7,9)**

PART - B (5 × 12 = 60 Marks)
[Essay Answer Type]

Note: Answer all the questions by using internal choice in not exceeding four pages each.

6. (a) What is process design? Explain factors effecting process design. **(Unit-I, Q.No.25,26)**

OR

(b) Define product life cycle and process life cycle. Discuss its process. **(Unit-I, Q.No.32,33)**

7. (a) What is Plant Layout? Discuss the various types of Plant Layout highlighting their merits and demerits. **(Unit-II, Q.No.14,18,19,21,22)**

OR

(b) From the following data, find the sequence that minimizes the total elapsed time. Also calculate the machine idle time and Job Waiting time.

Jobs	A	B	C	D	E	F	G
M-1	7	12	11	8	13	12	11
M-2	8	7	6	9	5	8	7
M-3	10	11	9	15	9	10	16

Ans :

Step 1

John's Rule (Extension)

i) Min $M_1 \geq$ Max M_2

$7 \not\geq 9$

ii) Min $M_3 \geq$ Max M_2

$9 \geq 9$

Condition is satisfied

Step 2

$G = M_1 + M_2$

$H = M_2 + M_3$

Jobs	G	H
A	15	18
B	19	18
C	17	15
D	17	24
E	18	14
F	20	18
G	18	23

Step 3

John's Rule

A	D	G	F	B	C	E

Computation of time

	Machine 1				Machine 2				Machine 3			
Jobs	**In time**	**Process time**	**Out time**	**Idle time**	**In time**	**Process time**	**Out time**	**Idle time**	**In time**	**Process time**	**Out time**	**Idle time**
A	0	7	7	0	7	8	15	7	15	10	25	15
D	7	8	15	0	15	9	24	0	25	15	40	0
G	15	11	26	0	26	7	33	2	40	16	56	0
F	26	12	38	0	38	8	46	5	56	10	66	0
B	38	12	50	0	50	7	57	4	66	11	77	0
C	50	11	61	0	61	6	67	4	77	9	86	0
E	61	13	74	0+21	74	5	79	7+16	86	9	95	0

Total elapsed time = 95 minutes

Idle Time

Machine - 1 = 21

Machine - 2 = 45 (7 + 2 + 5 + 4 + 4 + 7 + 16)

Machine - 3 = 15 (15)

Waiting Time

Waiting time of jobs between machine 1 and machine 2 is zero.

Waiting time of Jobs between machine 2 and 3 is 1 + 7 + 10 + 9 + 10 + 7 = 44 hours

Machine 3 has to wait for 44 hours for leading resulting in some in process inventory cost.

8. (a) What is service management? Explain various types of service operations. **(Unit-III, Q.No.11,14,15,16,17)**

OR

(b) What is work measurement? Discuss various techniques and methods. **(Unit-III, Q.No.8,11)**

9. (a) What is materials management? Explain its importance and advantages. **(Unit-IV, Q.No.1,3)**

OR

(b) Explain the concept of materials requirements planning. Its advantages and disadvantages. **(Unit-IV, Q.No.4,5)**

10. (a) The annual requirement of an item in a firm is 1,44,900 units. The cost of placing an order is ` 450 and the carrying cost per unit per annum is 10% of the cost of the item. The cost per unit of the item is ` 36. You are required to find the EOQs the number of orders to be placed in a year with the above data and when (i) the cost of the item decreases by 12% and (ii) the cost per order increases by ` 75.

Ans :

Annual Demand = 1,44,900 units

Cost per unit (c) = 36

Order cost = 450

Carrying Cost = 36 × 10% = 3.6

$$\sqrt{\frac{2\times 1,44,900\times 450}{3.6}}$$

= 6018.72 Units

(i) EOQ the cost of item decreased by 12%

Cost of item = 36

$$= 36\times \frac{12}{100} = 4.322$$

36 – 4.32 = 31.68

Carrying cost = 31.68 × 10% = 3.17

$$EOQ = \sqrt{\frac{2\times 1,44,900\times 450}{3.17}} = 6423.95 \text{ units}$$

(ii) EOQ when cost per order Increased by 75.

Ordering cost 450 + 75 = 525

$$EOQ = \sqrt{\frac{2\times 1,44,900\times 525}{3.6}}$$

= 6501 units

OR

(b) A manufacturing firm uses 12 items in its process. The annual requirement of the items and their cost is given below:

Item	Annual Requirement (units)	Cost per unit (Rs.)
A	9000	140
B	3600	600
C	240	2300
D	4300	340
E	656	945
F	656	945
G	18,000	50
H	11,500	80
I	3,500	540
J	600	1800
K	175	3200
L	480	2150

You are required to classify the materials into ABC categories and give a graphical presentation of the same.

Ans :

Calculation of Annual Consumption Value

Item	Annual Units	Cost Per Unit	Annual consumption Value
A	9,000	140	12,60,000
B	3,600	600	21,60,000
C	240	2300	5,52,000
D	4,300	340	14,62,000
E	656	945	6,19,920
F	656	945	6,19,920
G	18,000	50	9,00,000
H	11,500	80	9,20,000
I	3,500	540	18,90,000
J	600	1800	10,80,000
K	175	3200	5,60,000
L	480	2150	10,32,000

Step - 2 :

Rearrange the item in the descending order of annual consumption value and calculate cumulative ACV

Item	Annual consumption value	Cumulative annual consumption value
B	21,60,000	21,60,000
I	18,90,000	40,50,000
D	14,62,000	55,12,000
A	12,60,000	67,72,000
J	10,80,000	78,52,000
L	10,32,000	88,84,000
H	9,20,000	98,04,000
G	9,00,000	1,07,04,000
E	6,19,920	1,13,23,920
F	6,19,920	1,19,43,840
K	5,60,000	1,25,03,840
C	5,52,000	1,30,55,840
Total	**1,30,55,840**	

ABC classification is not given in the problem assume.

Category	ACV
A	70%
B	20%
C	10%

Category A

$$70\% \text{ of ACV} = 1,30,55,840 \times \frac{70}{100} = 91,39,088$$

B, I, D, A, J, L fall under category 'A'.

Category B

Category (A + B) together 90% of ACV

$$1,30,55,840 \times \frac{90}{100}$$

$$= 1,17,50,256$$

H,G,E fall under category 'B'

Category C

F, K, C are finally under category 'C'

Step - 3 :

Categorization of items

A	B	C
B	H	F
I	G	K
D	E	C
A		
J		
L		

FACULTY OF MANAGEMENT

M.B.A III-Semester (CBCS) Examination

July/August - 2019

OPERATIONS MANAGEMENT

Time : 3Hours] **[Max. Marks : 80**

PART - A (5 × 4 = 20 Marks)
[Short Answer Type]

Note: Answer all the questions in not more than one page each.

ANSWERS

1. Process Design **(Unit-I, Q.No.25)**
2. Service Organizations **(Unit-II, Q.No.54)**
3. Preventive and Connective Maintenance Management **(Unit-III, Q.No.50)**
4. Material Requirement Planning **(Unit-IV, SQA-3)**
5. Selective Inventory Control. **(Unit-V, Q.No.25)**

PART - B (5 × 12 = 60 Marks)
[Essay Answer Type]

Note: Answer all the questions by using internal choice in not exceeding four pages each.

6. (a) Define production planning and control. Explain its advantages and disadvantages. **(Unit-I, Q.No.27,31)**

OR

(b) Explain the concept of products and services and draw the differences between them. **(Unit-I, Q.No.8,9)**

7. (a) What is Plant Layout? Write the different types of layouts. **(Unit-II, Q.No.14,18,19,21,22)**

OR

(b) A company is faced with seven tasks that have to be processed through two machines find the optimal sequence of the jobs to process and find the total completion time, idle time of machines and waiting time of the jobs.

Task	A	B	C	D	E	F	G
M-1	2.58	1.66	2.71	5.52	3.38	5.22	2.89
M-2	3.47	5.84	2.41	1.99	7.62	1.73	1.11

Ans :

John's Rule = | B | A | E | C | D | F | G |

Computation of Time

Task	Machine 1				Machine 2			
	In Time	Process Time	Out Time	Idle Time	In Time	Process Time	Out Time	Idle Time
B	O	1.66	1.66	0	1.66	5.84	7.50	1.66
A	1.66	2.58	4.24	0	7.50	3.47	10.97	0
E	4.24	3.38	7.62	0	10.97	7.62	18.59	0
C	7.62	2.71	10.33	0	18.59	2.41	21.00	0
D	10.33	5.52	15.85	0	21.00	1.99	22.99	0
F	15.85	5.22	21.07	0	22.99	1.73	24.72	0
G	21.07	2.89	23.96	0 + 1.87	24.72	1.11	25.83	0

Idle time M_1 = 1.87

M_2 = 1.66

Completion time = 25.83 hrs.

Calculation of Waiting Time

Task	Waiting Time
B	0
A	3.26 (7.50 – 4.24)
E	3.35 (10.97 – 7.62)
C	8.26 (18.59 – 10.33)
D	5.15 (21.00 – 15.85)
F	1.92 (22.99 – 21.07)
G	0.76 (24.72 – 23.96)

8. (a) In a Steel manufacturing firm over 8 hour shift a work measurement study was conducted. 6372 units were produced in 8 hour shift the idle time observed is 12%. Allowance is 18% of normal time you are required to find the standard time per unit produced, assuming a performance rating of 115%.

Ans :

$$\text{Normal Time} = \frac{OT \times R.F \times \%working}{\text{Number of Units}}$$

$$= \frac{8 \times 1.15 \times 0.88}{6372} = 0.0013$$

Allowance = 18% of Normal time

= 18% of 0.0013

= 0.000234

Standard Time = Normal Time + Allowance

= 0.0013 + 0.000234

= 0.001534

Standard Time = 0.001534.

OR

(b) In a manufacturing firm a time study was conducted for a job. The job was divided in to 4 elements and the time taken for each element was observed in 4 cycles. The details are as below:

Job Elements	Time per Cycle in Minutes				Performance Rating
	Cycle 1	Cycle 2	Cycle 3	Cycle 4	
A	2.42	2.66	2.75	2.58	105
B	1.88	1.69	2.02	2.00	120
C	2.89	3.12	3.00	2.92	110
D	3.44	4.33	3.23	4.03	90

You are required to find the normal time and standard time of the job by considering a relaxation allowance of 14%, contingency allowance of 4% and incentive of 18% for the job.

Ans :

Calculation of Mean Actual time for each Job.

Job Element	Mean Actual Time
A	$\frac{2.42+2.66+2.75+2.58}{4} = 2.60$
B	$\frac{1.88+1.69+2.02+2.00}{4} = 1.90$
C	$\frac{2.89+3.12+3.00+2.92}{4} = 3.00$
D	$\frac{3.44+4.33+3.23+4.03}{4} = 3.75$

Calculation of Normal Time

Mean actual time × Performance Rating

$A = 2.60 \times \frac{105}{100} = 2.73$

$B = 1.90 \times \frac{120}{100} = 2.28$

$C = 3.00 \times \frac{110}{100} = 3.30$

$$D = 3.75 \times \frac{90}{100} = 3.38$$

Job = 2.73 + 2.28 + 3.30 + 3.38 = 11.69 minutes

Calculation of Standard Time

Allowance = Relaxation allowance + Contingency allowance

= 14% + 4% = 18%

$$\text{Standard Time} = \text{Normal Time} \times \left(1 + \frac{\text{Allowances}}{100}\right)$$

$$= 11.69 \times \left(1 + \frac{18}{100}\right)$$

$$= 11.69 \times (1.18) = 13.79 \text{ Min}$$

Incentives = 18% of Job

= 0.18 × 13.79 = 2.48 Min.

9. (a) What is purchase management? Discuss its process and importance. **(Unit-IV, Q.No.8,10)**

OR

(b) Define vendor rating. Explain various methods of vendor rating. **(Unit-IV, Q.No.15,16)**

10. (a) Define stores management. Explain the functions of stores and material control. **(Unit-V, Q.No.14,16)**

OR

(b) Categories the inventory' as ABC based on the usage of item using ABC analysis.

Item No.	Unit Cost	Annual Demand
101	5	48,000
102	11	2,000
103	15	300
104	8	800
105	7	4,800
106	16	1,200
107	20	18,000
108	4	300
109	9	5,000
110	12	500

Ans :

Calculation of ACV

Item No.	Unit Cost	Annual Demand	ACV
101	5	48,000	2,40,000
102	11	2,000	22,000
103	15	300	4,500
104	8	800	6,400
105	7	4,800	33,600
106	16	1,200	19,200
107	20	18,000	3,60,000
108	4	300	1,200
109	9	5,000	45,000
110	12	500	6,000

Rearrange the items in descending order of ACV calculate Cumulative AC.

Item No.	Total Cost in Descending Order	Cumulative ACV
107	3,60,000	3,60,000
101	2,40,000	6,00,000
109	45,000	6,45,000
105	33,600	6,78,600
102	22,000	7,00,600
106	19,200	7,19,800
104	6,400	7,26,200
110	6,000	7,32,200
103	4,500	7,36,700
108	1,200	7,37,900

Since the basic for ABC Classification is not given in data assumes the following data

Category	Percentage of ACV
A	70%
B	20%
C	10%

Category 'A'

$$70\% \text{ of ACV} = \frac{70}{100} \times 7,37,900 = 5,16,530$$

The items 107 and 101 fall under 'A' category.

Category 'B'

Category (A + B) together accounts for 90% (70% + 20%) of ACV.

$$90\% \text{ of ACV} = \frac{90}{100} \times 7,37,900$$

$$= 6,64,110$$

The items 109 and 105 full under category.

Category 'C'

The Remaining items such as 102, 106, 104, 110, 103 and 108 fall under 'C' category.

Categorization of Items

A	B	C
107	109	102
101	105	106
		104
		110
		103
		108

FACULTY OF MANAGEMENT

M.B.A (CBCS) III- Semester Examination

Decembe - 2019

OPERATIONS MANAGEMENT

Time : 3 Hours] **[Max. Marks : 80**

Note : Answer all the questions from Part - A and Part - B

Each question carries 4 marks in Part - A and 12 marks in Part - B

SECTION - A - (5 × 4 = 20 Marks)

[Short Answer Type]

ANSWERS

1. Operations strategy **(Unit-I, Q.No.23)**
2. Service facility layout **(Unit-II, SQA-7)**
3. Service management **(Unit-III, Q.No.11)**
4. Bin Card, Double Bin and Stores Ledger. **(Unit-V, Q.No.23)**
5. Classification, codification, simplification and standardization of materials. **(Unit-V, Q.No.19,20,22)**

SECTION - B - (5 × 12 = 60 Marks)

[Essay Answer Type]

6. (a) What is process design? Explain factors effecting process design. **(Unit-I, Q.No.25,26)**

OR

(b) Define product life cycle and process life cycle. Discuss its process. **(Unit-I, Q.No.32,33)**

7. (a) What is Plant Layout? Discuss the various types of Plant Layout highlighting their merits and demerits. **(Unit-II, Q.No.18,19,21,22)**

OR

(b) From the following data, find the sequence that minimizes the total elapsed time. Also calculate the machine idle time and Job Waiting time.

Jobs	A	B	C	D	E	F	G
M-1	7	12	11	8	13	12	11
M-2	8	7	6	9	5	8	7
M-3	10	11	9	15	9	10	16

Ans :

John's Rule

Condition - I

Min $(M_1) \geq$ Max (M_2)

8 $\geq$ 9 (condition not satisfied)

Condition - II

$\text{Min } (M_3) \geq \text{Max } (M_2)$

$9 \geq 9$ (condition sartisfied)

Creates 2 ficitious machine

$G = M_1 + M_2$

$H = M_2 + M_3$

Jobs	G	H
A	15	18
B	19	18
C	17	15
D	17	24
E	18	14
F	20	18
G	18	23

Applying John's Rule :

Optimal sequence

F	B	E	C	A	G	D

Computation of time

	Machine (M_1)				Machine (M_2)				Machine (M_3)			
Jobs	In	Process time	Out time	Idle time	In	Process time	Out time	Idle time	In	Process time	Out time	Idle time
F	0	12	12	0	12	8	20	12	20	10	30	20
B	12	12	24	0	24	7	31	4	31	11	42	1
E	24	13	37	0	37	5	42	6	42	9	51	0
C	37	11	48	0	48	6	54	6	54	9	63	3
A	48	7	55	0	55	8	63	1	63	10	73	0
G	55	11	66	0	66	7	73	3	73	16	89	0
D	66	8	74	30	74	9	83	1+21	89	15	104	0

Total idle time (M_1) = 30

(M_2) = 54

(M_3) = 24

8. (a) What is service management? Explain various types of service operations. **(Unit-III, Q.No.11,13)**

OR

(b) What is work measurement? Discuss various techniques and methods. **(Unit-III, Q.No.9,10)**

9. (a) What is materials management? Explain its importance and advantages. **(Unit-IV, Q.No.1,2)**

OR

(b) Explain the concept of materials requirements planning. Its advantages and disadvantages. **(Unit-IV, Q.No.4,5)**

10. (a) The annual requirement of an item in a firm is 1,44,900 units. The cost of placing an order is Rs. 450 and the carrying cost per unit per annum is 10% of the cost of the item. The cost per unit of the item is Rs. 36. You are required to find the EOQs the number of orders to be placed in a year with the above data and when (i) the cost of the item decreases by 12% and (ii) the cost per order increases by Rs.75.

Ans :

Annual Demand (A) = 1,44,900 units

Ordering Cost (C_0) = 450

Carrying Cost (C_0) = 10% of cost of item

= 10% of 36

Cost per unit (c) = 3.6

(i) Economic order quantity (EOQ)

$$\Rightarrow \text{EOQ (Q)} = \sqrt{\frac{2AC_0}{C_c}}$$

$$= \sqrt{\frac{2\times 1,44,900\times 450}{3.6}}$$

$$= \sqrt{\frac{130,410,000}{3.6}} = \sqrt{36,225,000}$$

$$= 6,018.78 \cong 6019 \text{ units}$$

No.of order to be place in year

$$\text{No. of order place} = \frac{\text{Annual Demand}(A)}{\text{EOQ}(Q)}$$

$$= \frac{1,44,900}{6019}$$

$$= 24.07 \cong 24 \text{ orders}$$

(ii) It cost of an item increase by 12% what EOQ?

Cost of item = 36

12% of 36 = 4.32

36 + 4.32

New cost = 40.32

$$EOQ = \sqrt{\frac{2AC_0}{C_c}}$$

C_c = 10% of 40.32

= 4.032

$$= \sqrt{\frac{2 \times 1,44,900 \times 450}{4.032}}$$

$$= \sqrt{\frac{130,410,000}{4.032}}$$

$$= \sqrt{32,343,756}$$

= 5,687.156 $\cong$ 5687 units

No. of orders placed

$$= \frac{\text{Annual Demand}}{\text{EOQ}}$$

$$= \frac{1,44,900}{5.687}$$

= 25.47

= 25 orders

(iii) If cost per order increased by Rs. 75

What is EOQ = ?

Ordering cost (C_0) = 450

Increased cost ordering = 75 `

New cost = 450 + 75

= 525

$$EOQ\ (Q) = \sqrt{\frac{2 \times 1,44,900 \times 523}{3.6}}$$

$$= \sqrt{\frac{152,145,000}{3.6}}$$

$$= \sqrt{42,262,500}$$

= 6,500.96 $\cong$ 6,501 units

$$\text{No. of order place} = \frac{\text{Annual demand}}{\text{EOQ}} = \frac{1,44,900}{6501}$$

= 22.28

$\cong$ 22 orders

OR

(b) A manufacturing firm uses 12 items in its process. The annual requirement of the items and their cost is given below:

Item	Annual Requirement (units)	Cost per unit (Rs.)
A	9000	140
B	3600	600
C	240	2300
D	4300	340
E	656	945
F	656	945
G	18,000	50
H	11,500	80
I	3,500	540
J	600	1800
K	175	3200
L	480	2150

You are required to classify the materials into ABC categories and give a graphical presentation of the same.

Ans :

Step - 1 :

Determination of annual consumption

Item	Annual consumption × unit price	Annual consumption value (ACV)
A	9,000 × 14	12,60,000
B	3,600 × 600	21,60,000
C	240 × 2300	5,52,000
D	4,300 × 340	14,62,000
E	656 × 945	6,19,920
F	656 × 945	6,19,920
G	18,000 × 50	9,00,000
H	11,500 × 80	9,20,000
I	3,500 × 540	18,90,000
J	600 × 1800	10,80,000
K	175 × 3200	5,60,000
L	480 × 2150	10,32,000

Step - 2 :

Reaarange the item in the descending order of annual consumption value and calculate cumulative ACV

Item	Annual consumption value	Cumulative annual consumption value
B	21,60,000	21,60,000
I	18,90,000	40,50,000
D	14,62,000	55,12,000
A	12,60,000	67,72,000
J	10,80,000	78,52,000
L	10,32,000	88,84,000
H	9,20,000	98,04,000
G	9,00,000	107,04,000
E	6,19,920	113,23,920
F	6,19,920	119,43,840
K	5,60,000	125,03,840
C	5,52,000	130,55,840

Step - 3 :

Category	Percentage of total ACV
A	70
B	20
C	10

70% of total ACV = 0.70 × 130,55,840

= 91,39,088

Items B, I, D, A, J, L are comes under 'A' category

Category (A + B) together accounts of 90% of ACV

= 90% of 13055840 (or) 0.90 × 13055840

= 117,50,256

Items G, E are comes under 'B' category.

The remaining items E, F, K, C are comes under 'C' category.

FACULTY OF MANAGEMENT

M.B.A III-Semester (CBCS) Examination

November - 2020

OPERATIONS MANAGEMENT

Time : 2 Hours] **[Max. Marks : 80**

PART - A (5 × 4 = 20 Marks)
[Short Answer Type]

Note: Answer any FOUR questions.

ANSWERS

1. Factors affecting Process Design **(Unit-I, Q.No.26)**
2. Preventive Maintenance **(Unit-II, Q.No.50)**
3. Quality Control

Ans :

Quality control (QC) is a procedure or set of procedures intended to ensure that a manufactured product or performed service adheres to a defined set of quality criteria or meets the requirements of the client or customer. QC is similar to, but not identical with, quality assurance (QA). While QA refers to the confirmation that specified requirements have been met by a product or service, QC refers to the actual inspection of these elements.

4. Vendor Rating **(Unit-IV, Q.No.15)**
5. Bin Card **(Unit-V, SQA-10)**

PART - B (5 × 12 = 60 Marks)
[Essay Answer Type]

Note: Answer any FOUR Questions

6. Explain the transformation process model of operations management. Discuss the various types of production systems. Give examples? **(Unit-I, Q.No.20,25)**
7. Find use Job sequencing X and total elapsed time, Idle Times for the following data:

	J_1	J_2	J_3	J_4	J_5	J_6	J_7
M1	9	12	5	15	23	33	40
M2	10	6	11	20	7	25	53

Ans :

Jobs	M_1	M_2
J1	9	10
J2	12	6
J3	5	11
J4	15	20
J5	23	7
J6	33	25
J7	40	53

Optimal sequence

J_3	J_1	J_4	J_7	J_6	J_5	J_2

Computation of Time

Job	Machine 1				Machine 2			
As Per Sequence	In time	Process time	Out time	Idle time	In time	Process time	Out time	Idle time
J_3	0	5	5	0	5	11	16	5
J_1	5	9	14	0	16	10	26	0
J_4	14	15	29	0	26	20	46	0
J_7	29	40	69	0	69	53	122	23
J_6	69	33	102	0	122	25	147	0
J_5	102	23	125	0	147	7	154	0
J_2	125	12	137	23	154	6	160	0
				23				28

Total Idle time $M_1 = 23$

$M_2 = 28$, Elapsed Time = 160.

8. What is Facility Location? What are the factors affecting location? **(Unit-II, Q.No.10,11)**

9. Define Maintenance Management. What is the difference between Preventive Maintenance and Breakdown Maintenance? **(Unit-II, Q.No.42)**

Ans :

Nature	Preventive maintenance	Breakdown maintenance
Definition	Preventive maintenance (PM) is work that is scheduled based on calendar time, asset runtime, or some other period of time.	Breakdown maintenance (BM) is work that is only performed when a piece of equipment breaks down or has a downtime event.
Resources	Maintenance software for scheduling	Maintenance software for downtime triggers
Needed	Maintenance scheduler (for larger organizations) Preventive maintenance checklists	Necessary replacement equipment Lowers overall costs of noncritical manufacturing equipment
Pros	Extends the lifetime of assets Optimizes planning of maintenance and resources	Minimizes preventive maintenance costs on nonessential equipment
Cons	➢ Can be expensive to keep up over the long term ➢ Labor intensive due to constant maintenance tasks	➢ Can't be used for many types of equipment, especially safety equipment ➢ Requires careful planning and execution to work effectively

10.	Describe in brief the nature of services and its implications on Operations Management?	**(Unit-II, Q.No.11,12)**
11.	Define Work Study, its benefits and techniques?	**(Unit-III, Q.No.1,3,7)**
12.	What is the need and importance of Materials Management?	**(Unit-IV, Q.No.3)**
13.	Explain the concept of Value Analysis and its role in cost reduction?	**(Unit-IV, Q.No.18,20)**
14.	Explain in brief regarding the types of Inventory Control Models?	**(Unit-V, Q.No.7,8,9,10)**
15.	Discuss the classification, codification, simplification and standardization of Materials?	**(Unit-V, Q.No.19,20,21)**

FACULTY OF MANAGEMENT

MBA III - Semester (CBCS) Examination

February - 2021

OPERATIONS MANAGEMENT

Time : 2 Hours] **[Max. Marks : 80**

PART - A (4 × 5 = 20 Marks)

Note: Answer any Four questions.

ANSWERS

1. Operations strategy. **(Unit-I, Q.No.23)**
2. Master production scheduling. **(Unit-II, SQA.10)**
3. Time study. **(Unit-III, SQA.5)**
4. Manufacturing resource planning. **(Unit-IV, Q.No.6)**
5. Safety stock. **(Unit-V, SQA.2)**

PART - B (4 × 15 = 60 Marks)

Note: Answer any Four questions.

6. Explain the similarities and differences between products and services with suitable examples. **(Unit-I, Q.No.8,9)**
7. What is process technology and explain the different process technologies used in the production. **(Unit-I, Q.No.25)**
8. Define plant layout. Explain the characteristics of an ideal facility layout. **(Unit-II, Q.No.14,15)**
9. From the following data, find the sequence that minimizes the total elapsed time. Also calculate the machine idle time.

Jobs	A	B	C	D	E	E	G
M1	7	12	11	8	13	12	11
M2	8	7	6	9	5	8	7
M3	10	11	9	15	9	10	1

Sol :

Condition-1

Minimum of M1 $\geq$ Maximum of M2

$7 \not\geq 9$

Condition-2

Minimum of M3 $\geq$ Maximume of M2

$1 \not\geq 9$

Since both the conditions are not satisfied, CDS method must be adopted

Number of Stages = Number of Machines $-1 \Rightarrow 3 - 1 = 2$

Stage-I $\rightarrow$ Consider first and last machines (i.e., M1 and M3)

Stage-II $\rightarrow$ Consider addition of first two machines and last two machines (i.e., M1 + M2 and M2 + M3)

Stage-1

Consider M1 and M3 Machines

Jobs	A	B	C	D	E	F	G
M1	7	12	11	8	13	12	11
M3	10	11	9	15	9	10	1

Finding Optimal Sequence Using Johnson's Rule

The smallest processing time is 1 for G on machine 3. So, it has to be sequenced at extreme right,.

						G

The next smallest processing time is 7 for A on machine1. So, it is placed in the beginning of the sequence.

A						G

The next smallest processing time is 8 for D on machine 1. So, it is placed beside A.

A	D					G

The next smallest processing time is 9 for C and E. There is tie between C and E. In this case, processing time whose corresponding processing time is less is considered first. Here, corresponding time of C is less so it is placed before G and then E is placed before C.

A	D			E	C	G

The next smallest processing time is 10 for F on machine 3. So, it is placed before E and last B is placed after D. Therefore optimal sequence is,

A	D	B	F	E	C	G

Computation of Times for Stage-I Sequence

	Machine I				Machine II				Machine III			
Jobs	**In Time**	**Process Time**	**Out Time**	**Idle Time**	**In Time**	**Process Time**	**Out Time**	**Idle Time**	**In Time**	**Process Time**	**Out Time**	**Idle Time**
A	0	7	7	0	7	8	15	7	15	10	25	15
D	7	8	15	0	15	9	24	0	25	15	40	0
B	15	12	27	0	27	7	34	3	40	11	51	0
F	27	12	39	0	39	8	47	5	51	10	61	0
E	39	13	52	0	52	5	57	5	61	9	70	0
C	52	11	63	0	63	6	69	6	70	9	79	0
G	63	11	74	0	74	7	81	5	81	1	82	2
Total				0+(82-74) = 8				31+(82-81) = 32				17

Total elapsed time = 82

Idle time for machine 1 = 8

Idle time for machine 11 = 32

Idle time for machine 111 = 17

Stage -II

Consider (M1 + M2) and (M2 + M3) as M4 and M5 respectively.

	Jobs	A	B	C	D	E	F	G
M4	M1+M2	15	19	17	17	18	20	18
M5	M2 + M3	18	18	15	24	14	18	8

Finding Optimal Sequence Using Johnson's Rule

The smallest processing time is 8 for Job G on machine 5. So, it placed at the end of Sequence.

						G

The next smallest processing time is 14 for Job E on machine 5. So, it is placed before Job G in sequence.

					E	G

The next smallest processing time is 15 for both Job A and C. There is tie between Job A and Job C but as they are on different machines, we can place both at the same time i.e., Job C beside Job E and Job A at the starting of sequence.

A				C	E	G

The next smallest processing time is 17 for Job-D on machine M4. So, it is placed next to Job A.

A	D			C	E	G

The next smallest processing time is 18 which is on both Job B and Job F. As there is tie, considered lowest corresponding time and place Job B first beside Job C and Job F after Job D.

A	D	F	B	C	E	G

Computation of Times for Stage-II Sequence

	Machine I				Machine II				Machine III			
Jobs	**In Time**	**Process Time**	**Out Time**	**Idle Time**	**In Time**	**Process Time**	**Out Time**	**Idle Time**	**In Time**	**Process Time**	**Out Time**	**Idle Time**
A	0	7	7	0	7	8	15	7	15	10	25	15
D	7	8	15	0	15	9	24	0	25	15	40	0
F	15	12	27	0	27	8	35	3	40	10	50	0
B	27	12	39	0	39	7	46	4	50	11	61	0
C	39	11	50	0	50	6	56	4	61	9	70	0
E	50	13	63	0	63	5	68	7	70	9	79	0
G	63	11	74	0	74	7	81	6	81	1	82	2
Total				0+(82-74) = 8				31+(82-81) = 32				17

Total elapsed time = 82

Idle time for machine I = 8

Idle time for machine II = 32

Idle time for Machine III = 17

The sequence (out of the two stages) which gives the minimum total elapsed time is to be chosen. Since the elapsed time of both the sequences is same, both the sequences are optimum sequences.

10. Define work study and explain the advantages and objectives of work study. **(Unit-III, Q.No.1,3)**

11. Discuss in detail the scheduling challenges in various service operations. **(Unit-III, Q.No.14,15,16,17)**

12. What is materials requirements planning and explain the advantages and disadvantages of MRP? **(Unit-IV, Q.No.4,5)**

13. Define value analysis and explain the role of value analysis in reducing the cost with suitable examples. **(Unit-IV, Q.No.18,21)**

14. Explain the objectives and functions of stores management. **(Unit-V, Q.No.14,15)**

15. Discuss in detail about probabilistic models of inventory. **(Unit-V, Q.No.11,12,13)**

FACULTY OF MANAGEMENT

MBA (CBCS) III - Semester Examination

JULY / AUGUST - 2021

OPERATIONS MANAGEMENT

Time : 2 Hours] [Max. Marks : 80

Part - A (4 × 5 = 2 Marks)

Note: Answer any Four questions.

ANSWERS

1. Product life cycle Vs Process life cycle **(Unit-I, Q.No.34)**
2. Aggregated demand **(Unit-II, SQA.9)**
3. Service quality **(Unit-III, Q.No.19)**
4. Sources of supply of materials **(Unit-IV, Q.No.11)**
5. Bin card **(Unit-V, SQA.10)**

Part - B (4 × 15 = 60 Marks)

6. Define operations management and explain the evolution of operations management. **(Unit-I, Q.No.1,2)**
7. Explain the functions and objectives of production planning and control. **(Unit-I, Q.No.27,30)**
8. Define facility location and explain the factors affecting the facility location. **(Unit-II, Q.No.10,11)**
9.

Jobs	J1	J2	J3	J4	J5	J6	J7
M1	6	10	12	1	7	16	20
M2	4	8	5	12	1	19	30

Find the total elapsed time & Idle time of the above jobs.

Sol.:

Step-1 : Determination of Job Sequence

The least processing time is 1 hour for job 14 on machine M1. Hence job 14 must be placed at the beginning of the sequence.

J4						

Job J4 should not be considered for further sequencing.

The next least processing time in the reduced list is 4 hours for job J1 on machine M2. Hence, job J1 must be placed at the end of the sequence.

J4						J1

Job J1 should not be considered for further sequencing.

The next least processing time is 5 hours for J3 on machine M2. Hence, Job J3 must be placed in the second cell from right side (i.e., before Job J1)

J4					J3	J1

Job J3 should not be considered for further sequencing.

The next least processing time is 7 hours for Job J5 on machine M1. Hence, Job 15 must be placed in the second cell of the sequence.

J4	J5				J3	J1

Job J5 should not be considered for further sequencing.

The next least processing time is 8 hours for J2 on machine M2. Hence, Job J2 must be placed in the third cell from the right side (i.e., before Job J3).

J4	J5			J2	J3	J1

Job J2 should not be considered for further sequencing.

The next least processing time in the remaining list is 16 hours for Job on machine M1. Hence, job J6 must be placed in the third cell of the sequence.

J4	J5	J6		J2	J3	J1

Job J6 should not be considered for further sequencing .

Only job J7 is remaining now, so it must be placed in the left out cell. Therefore, optimum sequence is as follows,

J4	J5	J6	J7	J2	J3	J1

Step - 2 :

Computation of Total Elapsed Time and Idle Time

Machine M1				Machine M2				
Job Sequence	**In Time**	**Processing Time**	**Out Time**	**Ide Time**	**In Time**	**Processing Time**	**Out Time**	**Idle Time**
J4	0	1	1	0	1	12	13	1
J5	1	7	8	0	13	11	24	0
J6	8	16	24	0	24	19	43	0
J7	24	20	44	0	44	30	74	1
J2	44	10	54	0	74	8	82	0
J3	54	12	66	0	82	5	87	0
J1	66	6	72	0	87	4	91	0
				0 + (91–72) = 19				2

Total elapsed time = 91 hours (i.e., out time of last job on machine M2)

Idle time for machine M1 = 19 hours (i.e., difference between out time of last job on machine M2 and out time of last job on machine M1).

Idle time for machine M2 = 2 hours.

10. Explain the nature of services and detail the types of service operations. **(Unit-III, Q.No.12,13)**

11. What is work measurement? Discuss various techniques and methods of work measurement. **(Unit-III, Q.No.8,11)**

12. Explain the need and importance of materials management. **(Unit-IV, Q.No.3)**

13. What is vendor rating and explain the different methods of vendor rating. **(Unit-IV, Q.No.15,16)**

14. What is ABC analysis and explain the procedure to conduct the ABC analysis. **(Unit-V, Q.No.25)**

15. Discuss in detail about the deterministic models of inventory. **(Unit-V, Q.No.6,7,8,9,10)**

FACULTY OF MANAGEMENT

MBA III - Semester Examinations

August / September - 2022

OPERATIONS MANAGEMENT

Time : 3 Hours Max. Marks : 80

PART-A (5 × 4 = 20 Marks)

ANSWERS

Note : Answer any Five questions.

1. Define Batch Process Technology. **(Unit-I, SQA.8)**
2. What is Aggregate Planning? **(Unit-II, SQA.8)**
3. Explain Relationship between culture and service quality. **(Unit-III, Q.No.19,21)**
4. What is Value analysis? **(Unit-IV, SQA.8)**
5. What are Fixed period quantity systems? **(Unit-V, Q.No.12)**

PART-A (5 × 12 = 60 Marks)

6. (a) What is Agile Manufacturing System ? Explain about various methods of Agile Manufacturing. **(Unit-I, Q.No.21)**

OR

(b) Explain the functions of Production Planning & Control. **(Unit-I, Q.No.30)**

7. (a) Explain the different factors influencing the facility location. **(Unit-II, Q.No.16)**

OR

(b) Explain in detail about various types of maintenance policies. **(Unit-II, Q.No.47)**

8. (a) Describe the objectives and techniques of work measurement. **(Unit-III, Q.No.8,11)**

OR

(b) What are Scheduling challenges in various service operations? **(Unit-III, Q.No.14,15,16,17)**

9. (a) Explain the Need and importance of Materials management. **(Unit-IV, Q.No.3)**

OR

(b) Elaborate on different methods used for vendor rating. **(Unit-IV, Q.No.16)**

10. (a) Explain the importance and functions of inventory management. **(Unit-V, Q.No.3,4)**

OR

(b) Explain the importance of Codification and Standardization of materials in stores department. **(Unit-V, Q.No.19,20)**