Priyadarsini Mallick
(Lect, Mech)

Chapter -01

PLANT ENGINEERING

Plant: Plant is a place where men ,material ,money ,equipment ,machinery etc are utilised properly for manufacturing useful products.

Factors Affecting/Governing Plant Location: Plant location must be selected properly by entrepreneurs while planning to set up their business units. While taking such a decision, they must consider some important factors.

In practice, the choice of plant location should be based on following considerations

1. Availability of Raw material: An ideal location is one where the main raw-material required to manufacture the product is adequately available. This will ensure regular supply of the material and will also reduce the transportation costs. The technical and delivery problems associated with raw-material can be reviewed and discussed from time to time. Alternately, the per unit cost of raw-material should come out to be minimum at the ideal plant location.

2. Nearness to the potential market: Marketing of its product efficiently is also an important function of an enterprise. If the plant is located near the market, then the management can keep close touch with the changes in market environment and formulate its production policies accordingly. But with expansion of markets both on national and international levels this aspect has now become of secondary importance. But the reduction in marketing costs still remains an important consideration for location to be near the market. The transportation and other overheads are likely to increase with distance between plant and the market. Also, in case of factory being nearer to the market the risk of damage in transportation, loss of demand due to change in fashions etc. is also reduced. Glass and chemical factories are mainly affected by this consideration.

3. Availability of Fuel and Power: In some industries continuous and adequate supply of power is of great significance e.g. nylon fibber plant. There are some industries for which cheap electricity may be more important. In such situation location of the plant near to hydro-power stations will provide cheap electricity e.g. paper and pulp mills, flour mills etc.

4. Availability of labour: Labour is one of the most important inputs in an industrial enterprise. There should be regular and cheap supply of labour, specifically for unskilled labour. in modern times with brisk movement of labour force from one place to other this factor is also of secondary importance. But if

there is adequate supply of local labour near the plant then naturally it will be available at cheaper rates.

5. Transport and Communication facilities : Transport is very important for bringing raw materials, fuel from different places. Also transport is required to supply the finished products to markets. The region well connected with Rail, Road, Water and Air transport system is considered to be more appropriate for the location of plants. Similarly good communication facilities viz. Postal and Telecommunication links are of great significance towards the success of an enterprise. Regions with good communication system should be given priority for the selection of sites. Similarly, Industries producing goods for export may be located near ports or airports.

6. Availability of Water : Water is used for processing as in paper and chemical industry and is also required for drinking and sanitation purpose. Depending upon the nature of plant , water should be available in adequate quantity .

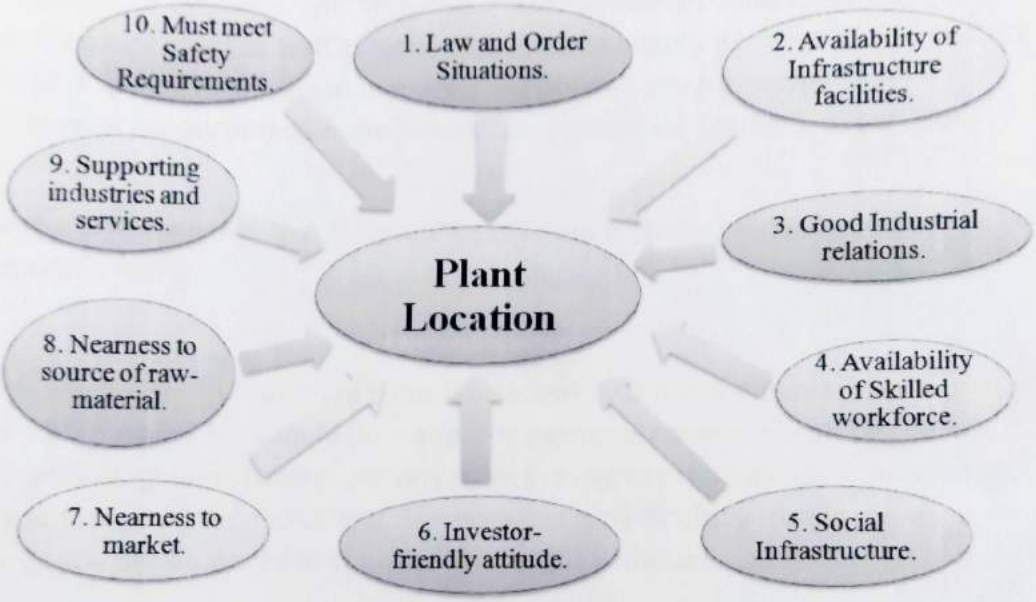
7. Integration with other group of companies : New enterprise owned or operated by a single group of companies should be so located that its work can be integrated with the work of the associated establishments.

8. Suitability of land and climate : Sub-soil of the location should be able to support the load likely to be placed on it. Similarly, the climatic conditions viz, humidity, temperature and other atmospheric conditions should be favourable for the plant e.g. damp climate is favourable for textile and cotton industries. These conditions also determine heating and ventilating requirements.

9. Availability of housing, amenities and other services: Good housing facility, adequate number of shops, theatres, cinemas, restaurants, local passenger transport and rail services and sufficient availability of gas, water supply, drainage, disposal of waste, fire fighting services can easily attract goods stoff.

10. Local building and planning regulations: Proposed location should not infringe local regulations and bye-laws. A discussion with the survey department of the local authority is most desirable. Laws for the construction of buildings, local taxes etc should be taken into consideration for the selection of site.

11. Safety requirements: industries like nuclear power stations, explosive in nature, chemical process likely to pollute the atmosphere should be located in remote areas. Safety from enemy during the war periods also affects location decision.



Factors affecting plant location

Other factors which also affect plant location are availability and cost of land, suitability of land - soil and topography, climatic conditions, location of a similar unit, etc.

1.2 PLANT LAYOUT

DEFINATION: Plant layout means the disposition of the various facilities (equipment's, material, manpower etc.) within the areas of the site selected. Plant layout begins with the design of the factory building and goes up to the location and movement of work. All the facilities like equipment, raw material, machinery, tools, fixtures, workers etc. are given a proper place.

1.3 OBJECTIVES OF PLANTLAYOUT:

The principal objective of a proper plant layout is to maximize the production at the minimum of the costs. This objective should be kept in mind while designing a layout for a new plant as well as while making the necessary changes in the exiting layout in response to change in management policies and processes and techniques of production with the production system, i.e. workers, supervisors and managers.

If a layout is to fulfil this goal, it should be planned with the following clear objectives in mind.

There is the proper utilization of cubic (i.e. length, width and height). Maximum use of volume available should be made. For example, conveyors can be run above head height and used as moving work in progress or tools and equipment's can be suspended from the ceiling. The principle is particularly true in stores where goods can be stored at considerable height without inconvenience.

a) Waiting time of the semi-finished products is minimized.
b) Working conditions are safer, better (well ventilated rooms etc.) and improved
c) Material handling and transportation is minimized and efficiently controlled. For this, one has to consider the movement distances between different work areas as well as the number of times such movements occur per unit period of time.
d) The movements made by the worker are minimized.
e) Suitable spaces are allocated to production centres
f) Plant maintenance is simpler.
g) There is increased flexibility for changes in product design and for future expansion. It must be capable of incorporating, without major changes, new equipment to meet technological requirement or to eliminate waste.

h) A good layout permits material to move through the plant at the desired speed with the lowest cost.
i) There is increased productivity and better product quality with reduced capital cost.
j) Boosting up employee morale by providing employee comforts and satisfaction.
k) The work should be so arranged the there is no difficulty in supervision, coordination and control. There should be no 'hiding-places' into which goods can be mislaid. Goods — raw materials and ready stocks — must be readily observed at all times. It will reduce the pilferage of material and labour.

1.3 PRINCIPLES OF PLANTLAYOUT: While designing the layout of a plant, the following principles should be kept in mind:

(i) Principle of minimum movement: As far as possible materials and labour should be moved over minimum distances.

(ii) Principle of flow: The work areas should be arranged according to the sequence of operations so that there is a continuous flow of materials without backtracking or congestion. The layout should allow for easy movement of materials without interruptions or delays. As far as possible movement of materials should be continuous.

(iii) Principle of space: All available cubic space should be effectively used both horizontally and vertically.

(iv) Principle of safety. Due consideration should be given to the safety and convenience of workers. There should be built-in provision for the safety and comfort of employees.

(v) Principle of flexibility. Layout should be so designed that production facilities can easily be rearranged when it becomes necessary in future on account of expansion or technological changes.

(vi) Principle of interdependence. Interdependent operations and processes should be located in close proximity to each other. For example, materials should be stored near the area of requirement, transport, etc. This will minimize product travel.

(vii) Principle of overall integration. All the plant facilities and services should be fully integrated into a single operating unit so as to maximize efficiency and minimize costs of production.

(viii) Principle of minimum investment. The layout should yield savings in fixed capital investment through optimum utilization of available facilities.

1.4 TYPES OF PLANT LAYOUT:

There are three main types of plant layout:

1) Functional or Process layout

2) Product or Line Layout,

(3) Combination Layout

4) Fixed Position Layout.

However, the choice of one or the other type of layout depends upon the machines and techniques used in the production.

(1)Process Layout:

Process layout is a design for the floor plan of a plant which aims to improve efficiency by arranging equipment according to its function.It is also known as the functional layout and is characterized by keeping similar machines orsimilar operations at one location (place). In other words, separate departments are establishing for each specializes operation of production and machines relating to that functions are assembled there.

Advantages of Process Layout:

The following advantages of Process Layout below are;

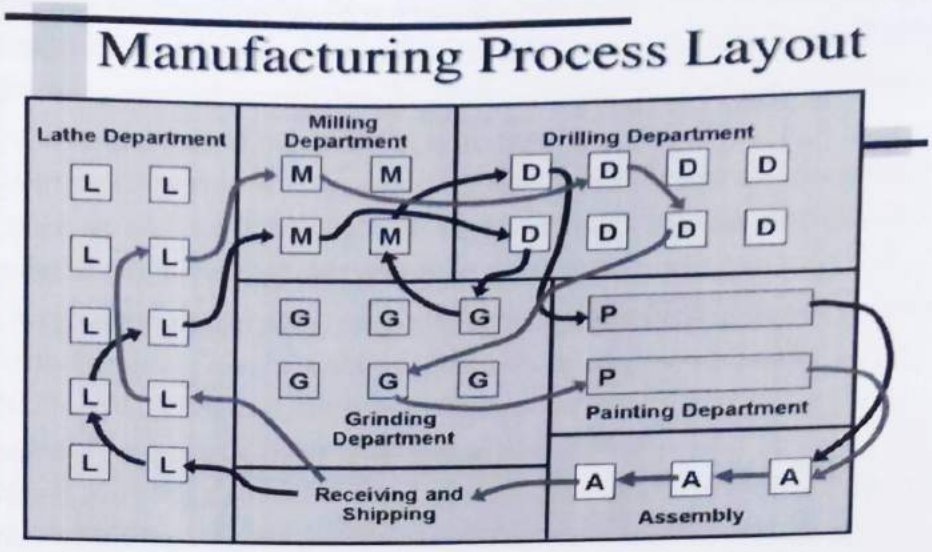
a) Wide flexibility exists as regards allotment of work to equipment and workers. The production capacity does not arrange in rigid sequence and fixed-rate capacity with line balancing. Alteration or change in the sequence of operations can easily make as and when required without upsetting the existing plant layout plan.
b) Better quality product, because the supervisors and workers attend to one type of machines and operations.

c) Variety of jobs, coming as different job orders make the work more interesting for workers.
d) Workers in one section do not affect by the nature of operations carried out in another section. e.g. a lathe operator does not affect by the rays of welding as the two sections are quite separate.
e) The breakdown of one machine does not interrupt the entire production flow.
f) This type of layout requires lesser financial investment in machines and equipment because general-purpose machines, which are usually of low costs, are used and duplication of the machine avoids. Moreover, general-purpose machines do not depreciate or become obsolete as rapidly as specialized machines. It results in lower investment in machines.
g) Under process layout, better and efficient supervision is possible because of specialization in operation.

Disadvantages of Process Layout:

The following disadvantages of Process Layout below are;

a) Automatic material handling is extremely difficult because fixed material handling equipment like conveyor belt cannot be possible to use.
b) Completion of the same product takes more time.
c) Raw material has to travel larger distances for getting processed to finished goods. This increases material handling and associated costs.
d) It is not possible to implement the group incentive schemes based on the quantity of the manufacturing of the product.
e) This type of layout requires more floor space than the product layout because a distinct department established for each operation.
f) Compared to line layout inventory investments are usually higher in case of process layout. It increases the need for working capital in the form of inventory.
g) Under process layout, cost of supervision is high because; 1) the number of employees per supervisor is less than result in the reducedsupervisory span of control2) the work is checked after each operation



PRODUCT LAYOUT

It is also known as line (type) layout. It implies that various operations on a product are performed in a sequence and the machines are placed along the product flow line i.e., machines are arranged in the sequence in which a given product will operate upon. This type of layout prefers for continuous production i.e., involving a continuous flow of in-process material towards the finished product stage.

Advantages of Product Layout:

The following advantages of Product Layout below are;

- Automatic material handling, lesser material handling movements, time and cost.
- **Product completes in lesser time. Since materials are fed at one end of the layout and the finished product collects at the other end, there is no transportation of raw materials backward and forward**. It shortens the manufacturing time because it does not require any time-consuming interval transportation until the completion of the process of production. Line balancing may eliminate idle capacity.

- **The smooth and continuous flow of work. This plan ensures a steady flow of production with the economy because bottlenecks or stoppage of work at different points of production is got to eliminate or avoid due to the proper arrangement of machines in sequence.**
- Less in-process Inventory. The semi-finished product or work-in-progress is the minimum and negligible under this type of layout because the process of production is direct and uninterrupted.
- Effective quality control with reduced inspection points. It does not require frequent changes in machine set-up. Since the production process integrates and continuous, Defective practice can easily discover and segregate. This makes inspection easy and economical.
- Maximum use of space due to straight production flow and reduced need for interim storing.

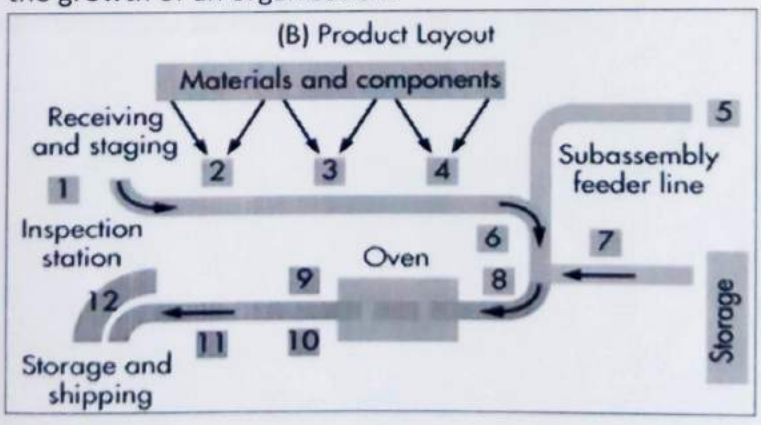
IN SHORT

- **product layout is preferably used for several continuous processes industries because of automated work.**
- **The product layout also requires less manpower when compared to other industries.**
- **It involves the optimization of land resources and financial resources.**
- **Very less scope for manual mistakes with the product layout.**
- **It doesn't require much scheduling and manpower.**
- **Most of the work has been done by automated machines and no need to move them from a place to another.**

Disadvantages of Product Layout:

The following disadvantages of Product Layout below are;

- Since the specific product determines the layout, a change in product involves major changes in layout and thus the layout flexibility considerably reduces.
- The pace or rate of working depends upon the output rate of the slowest machine. This involves excessive idle time for other machines if the production line does not adequately balance.
- Machines being scattered along the line, more machines of each type have to purchase for helping a few as stand by, because if one machine in the line fails, it may lead to shut down of the complete productionline.
- It is difficult to increase production beyond the capacities of the production lines.
- Since there are no separate departments for various types of work, supervision is also difficult.
- The product layout requires huge amounts of investment and large space to place the equipment.
- Frequent disturbances like repairs, power fluctuations, etc will be faced by the product layout.
- The product layout requires human resources for the supervision process. And they need to pay high amounts for them.
- It is not easy to expand the product layout which becomes a risk factor for the growth of an organization.



EXAMPLES PRODUCT LAYOUT

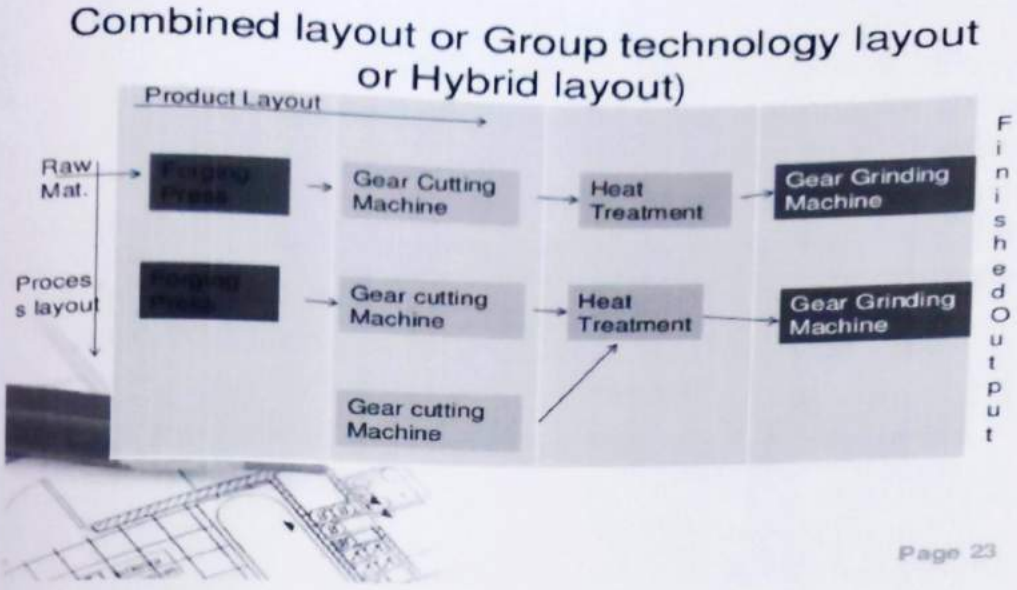
The product layout examples are majorly manufacturing units and continuous processes. Certain industries like sugar, paper, cement are the best examples. Also, automobile industries, electronic appliances like printers, refrigerators were using these product layouts for manufacturing. Our daily needs like food, paper, etc manufactured which is the help of product layout. The product layouts are preferably used for large scale industries having continuous processes.

COMBINATION LAYOUT:

A combination of process and product layouts combine the advantages of both types of layouts. Moreover, these days pure product or process layouts are rare. Most of the manufacturing sections are arranging in process layout with manufacturing lines occurring here and there (scattered) wherever the conditions permit. A combination layout is possible where an item makes in different types and sizes.

A combination layout is also useful when several items are producing in the same sequence but none of the items are to produce in bulk and thus no item justifies for an individual and independent production line. For example, files, hacksaws, circular metal saws, wood saws, etc. can manufacture on a combination type of layout.

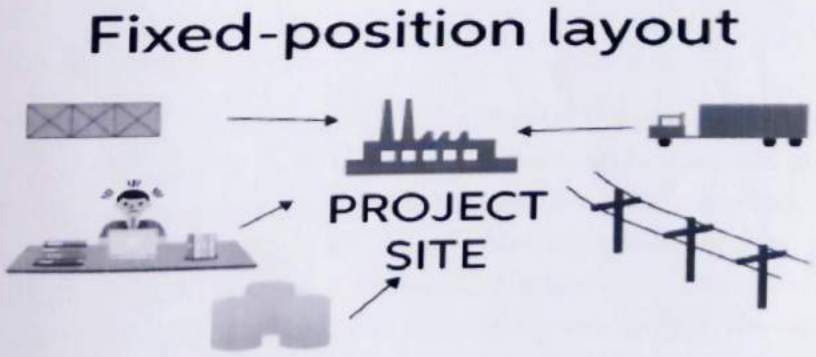
Flexibility is a very important factory, so the layout should be such which can mould according to the requirements of the industry, without much investment. If the good features of all types of layouts are connecting, a compromise solution can obtain which will be more economical and flexible.



Fixed Position Layout:

This type of layout is the least important for today's manufacturing industries. In this type of layout, the major component remains in a fixed location, other materials, parts, tools, machinery, manpower and other supporting equipment's are brought to this location.

In other types of layouts discussed earlier, the product moves past stationary production equipment, whereas in this case the reverse applies; men and equipment are moving to the material, which remains at one place and the product completes at that place where the material lies.



TECHNIQUES TO IMPROVE PLANTLAYOUT

In plant layout various types of techniques are used to arrange the work in co-ordination manner. The techniques arrange the quickest flow of material at lower cost and with lesser handling in processing the product from the acknowledged of the raw material to the shipment of finished product. The technique arranges that which method is done, which material is used to performed in which machine all the process are arranged by the plant layout technique. There are some types of tools and techniques are discussed below.

The following tools are used, in layout planning:

- Operation process charts
- Flow process charts
- Flow diagrams
- Machine data cards
- Templates
- Scale models
- Layout drawings

A. Operation Process Chart

With the help of operation process chart, we can separate and arrange the process of materials moving to which machine and work done under which method all types of operation are arranged by operation process chart .The operation process chart is mainly used when a new plant is to be laid out. This process chart shows basic activities for producing a product. These carts show the overall visualization with help of elimination, combination, rearrangement or simplification of process and basis for studying possibilities for the improvement operation.

B. Flow Process Chart

All the production activities occurring on the floor of the plant are representing graphically in flow process chart. The flow process chart real work is to tracing the actual flow of work occurring and the time required for the operation. It works on transportation, storage and delay. The complete information for the analysis and improvement of plant operation is provided by flow process chart. The result of analysis operation may be eliminated, combined or rearranged. The work station, storage area can be rearranged to reduce travelling distance and labour time. The

flow process chart also checks and verify the efficiency of proposed floor plan for a new layout.

C. Flow Diagram

The flow diagram is used to supplement of the flow process chart. it is graphically representing of work area, machinery, storage area, gang way etc. which path is followed by men or materials is marked on flow diagram. All the symbols and straight lines are joining with each other and make routes to follow by different item are shown in flow diagram. In flow process chart will trace out the undesirable characteristic of layout which is responsible for delay and increasing transportation by study the process flow diagram and flow process chart. It is also show nature of back tracking to help on improving the layout and easy to trace and present layout attractive.

D. Machine Data Cards

This is effective tool to provide full information for placement or layout of equipment. The card shows the machine capacity, space and power requirement, handling devices and corresponding dimensions.

E. Templates

The area taken by a machine is cut to scale from a thick paper is cut to scale from a thick paper to form a template. Not only machine but space covered by furniture, equipment and other components can also form a template these can be shown the well-arranged actual plan of layout to be undertaken. The template technique is an important technique because Unnecessary handling is eliminated, backtracking of materials is minimized, the mechanical handling is possible, and it offers flexibility to meet future changes in the production requirements.

F. Scale Models

Scale model provide a three-dimensional layout it is better understanding models are used to represent real situation the colour cording can be used to define the plant perfectly and easily understand. The scale model is available for large range of machine tools, equipment, bench, storage cupboard etc. the typical type of models is shown in three-dimensional layout. The model is expensive in this model reduce explanation since the other layout.

1.6 Material Handling

Manual material handling ranges from movement of raw material, work in progress, finished goods, rejected, scraps, packing material, etc. These materials are of different shape and sizes as well as weight. Material handling is a systematic and scientific method of moving, packing and storing of material in appropriate and suitable location. The main objectives of material handling are as follows:

- It should be able determine appropriate distance to be covered.
- Facilitate the reduction in material damage as to improve quality.
- Reducing overall manufacturing time by designing efficient material movement
- Improve material flow control
- Creation and encouragement of safe and hazard-free work condition
- Improve productivity and efficiency
- Better utilization of time and equipment

It is critical for manufacturing organization to identify importance of material handling principle as the critical step in promoting the job improvement process. Manual material handling significantly increases health hazard for the workers in from lower back injuries.

In the current competitive and globalized environment, it is important to control cost and reduce time in material handling. An efficient material handling process promotes:

- Design of proper facility layout
- Promotes development of method which improves and simplifies the work process
- It improves overall production activity.
- Efficient material handling reduces total cost of production.

Principles of Material Handling: -

Material handling principles are as follows:

- **Orientation Principle:** It encourages study of all available system relationships before moving towards preliminary planning. The study includes looking at existing methods, problems, etc.
- **Planning Principle:** It establishes a plan which includes basic requirements, desirable alternates and planning for contingency.
- **Systems Principle:** It integrates handling and storage activities, which is cost effective into integrated system design.
- **Unit Load Principle:** Handle product in a unit load as large as possible
- **Space Utilization Principle:** Encourage effective utilization of all the space available
- **Standardization Principle:** It encourages standardization of handling methods and equipment.
- **Ergonomic Principle:** It recognizes human capabilities and limitation by design effective handling equipment.
- **Energy Principle:** It considers consumption of energy during material handling.
- **Ecology Principle:** It encourages minimum impact upon the environment during material handling.
- **Mechanization Principle:** It encourages mechanization of handling process wherever possible as to encourage efficiency.
- **Flexibility Principle:** Encourages of methods and equipment which are possible to utilize in all types of condition.
- **Simplification Principle:** Encourage simplification of methods and process by removing unnecessary movements
- **Gravity Principle:** Encourages usage of gravity principle in movement of goods.
- **Safety Principle:** Encourages provision for safe handling equipment according to safety rules and regulation

- **Computerization Principle:** Encourages of computerization of material handling and storage systems
- **System Flow Principle:** Encourages integration of data flow with physical material flow
- **Layout Principle:** Encourages preparation of operational sequence of all systems available
- **Cost Principle:** Encourages cost benefit analysis of all solutions available
- **Maintenance Principle:** Encourages preparation of plan for preventive maintenance and scheduled repairs
- **Obsolescence Principle:** Encourage preparation of equipment policy as to enjoy appropriate economic advantage.

Material handling operations are designed based upon principles as discussed above. Material handling equipment consists of cranes, conveyors and industrial trucks.

IN DETAIL

1. Orientation Principle

Study the system relationships thoroughly prior to preliminary planning in order to identify existing methods and problems, physical and economic constraints, and to establish future requirements and goals.

2. Planning Principle

Establish a plan to include basic requirements, desirable options, and the consideration of contingencies for all material handling and storage activities.

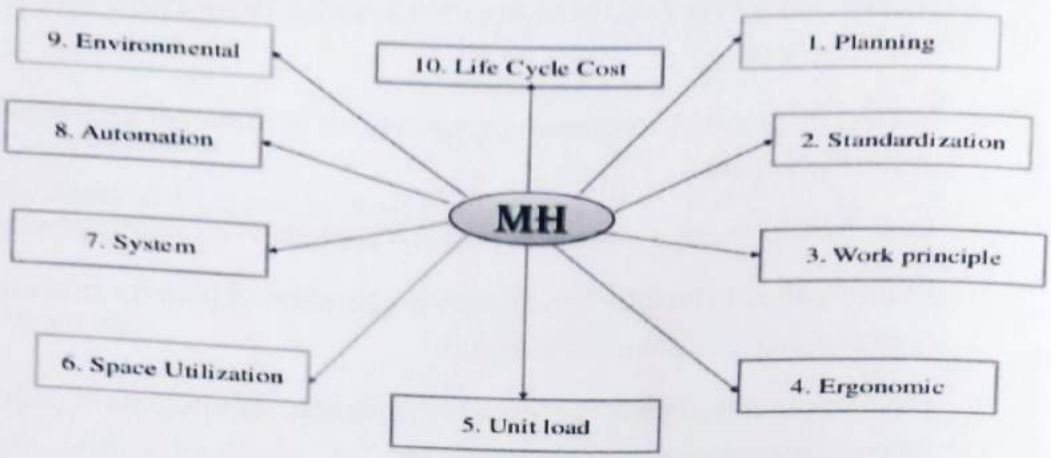
3. Systems Principle

Integrate those handling and storage activities which are economically viable into a coordinated system of operation including receiving, inspection, storage, production, assembly, packaging, warehousing, shipping and transportation.

4. Unit Load Principle

Handle product in as large a unit load as practical.

MH-PRINCIPLES



Principles Of Material Handling

5. Space Utilization Principle Make effective utilization of all cubic space.

6. Standardization Principle Standardize handling methods and equipment wherever possible.

7. Ergonomic Principle Recognize human capabilities and limitations by designing material handling equipment and procedures for effective interaction with the people using the system.

8. Energy Principle Include energy consumption of the material handling systems and material handling procedures when making comparisons or preparing economic justifications.

9. Ecology Principle Minimize adverse effects on the environment when selecting material handling equipment and procedures.

10. Mechanization Principle Mechanize the handling process where feasible to increase efficiency and economy in the handling of materials.

11. Flexibility Principle Use methods and equipment which can perform a variety of tasks under a variety of operating conditions.

12. Simplification Principle Simplify handling by eliminating, reducing, or combining unnecessary movements and/or equipment.

13. Gravity Principle Utilize gravity to move material wherever possible, while respecting limitations concerning safety, product damage and loss.

14. Safety Principle Provide safe material handling equipment and methods which follow existing safety codes and regulations in addition to accrued experience.

15. Computerization Principle Consider computerization in material handling and storage systems, when circumstances warrant, for improved material and information control.

16. System Flow Principle Integrate data flow with the physical material flow in handling and storage.

17. Layout Principle Prepare an operational sequence and equipment layout for all viable system solutions, then select the alternative system which best integrates efficiency and effectiveness.

18. Cost Principle Compare the economic justification of alternate solutions in equipment and methods on the basis of economic effectiveness as measured by expense per unit handled.

19. Maintenance Principle Prepare a plan for preventive maintenance and scheduled repairs on all material handling equipment.

20. Obsolescence Principle Prepare a long range and economically sound policy for replacement of obsolete equipment and methods with special consideration to after-tax life cycle costs.

1.7 PLANT MAINTENANCE:

Plant maintenance is defined as a set of activities that are necessary to keep machinery, parts & types of equipment in good operating conditions to avoid production stoppage and loss.

Objectives of maintenance management.

1. Minimizing the loss of production time due to equipment failure
2. To reduce loss due to the production stoppage.
3. To keep all productive assets in good working conditions
4. Improve the quality of the product and to improve productivity
5. Helps to reduce the total maintenance cost of repair, preventive maintenance & inventory carrying a cost due to a spare part inventory.

1.7.1 IMPORTANCE OF PLANT MAINTENANCE:

1. Machines and other facilities should be kept in such a condition which permits them to be used at their optimum (profit making) capacity without any interruption or hindrance.
2. Maintenance division of the factory ensures the availability of the machines, buildings and services required by other sections of the factory for the performance of their functions at optimum return on investment whether this investment be in material, machinery or personnel.
3. An un-properly maintained or neglected plant will sooner or later require expensive and frequent repairs, because with the passage of time all machines other facilities (such as transportation facilities), buildings, etc., wear out and need to be maintained to function properly.
4. Broken equipment always leads to lost production. If you depend on a steady fl of production, such as in a factory, then broken equipment will shut down the line. In a power plant, a broken boiler or material handling system will immediately drop output.

TYPES OF PLANT MAINTENANCE

Maintenance may be classified into following categories:

(a) Corrective or breakdown maintenance

(b) Scheduled maintenance

(c) Preventive maintenance

(d)Preventive maintenance

1.7.2 BREAK DOWN MAINTENANCE

This is also called corrective maintenance it occurs when work gets stopped because of a machine breakdown. In this sense, maintenance becomes repair work. Repairs are made after the equipment is out of order

Some examples in which breakdown maintenance is applicable:

Equipment can't be repaired at all (inaccessible, designed to not be repaired)

Asset consists of inexpensive or easy-to-replace parts

Non-critical pieces of equipment (like hand tools)

Objects/equipment that are disposable or meant to be replaced at the end of their lifespan.

Typical Causes of Equipment Breakdown:

(i) Failure to replace worn out parts.

(ii) Lack of lubrication.

(iii) Neglected cooling system.

(iv) Indifference towards minor faults.

(v) External factors (such as too low or too high line voltage, wrong fuel, etc.)

(vi) Indifference towards -equipment vibrations, unusual sounds coming out of the rotating ma-chinery, equipment getting too much heated up, etc. Short-life assets (batteries, high flow pumps)

Disadvantages of Breakdown Maintenance:

(i) Breakdowns generally occur at inopportune times. This leads to poor, hurried maintenance and excessive delays in production.

(ii) Reduction of output.

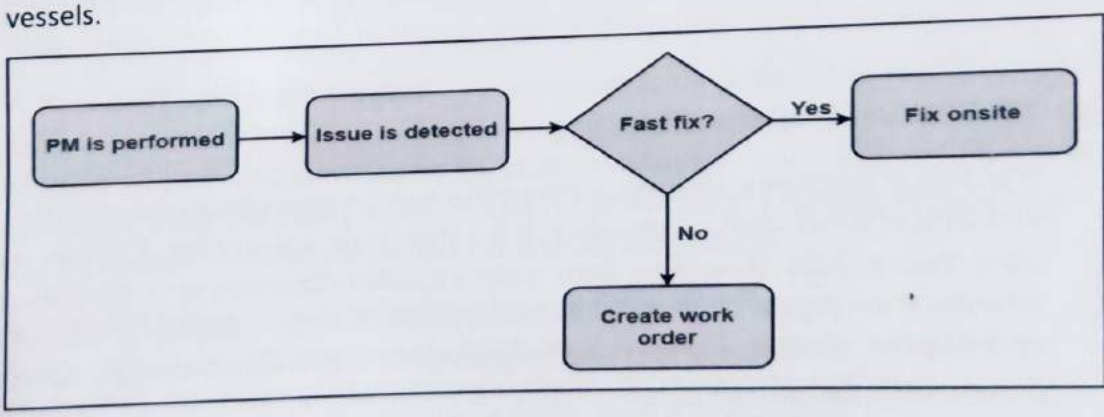
(iii) Faster plant deterioration.

(iv) Increased chances of accidents and less safety to both workers and machines.

(v) More spoilt material.

(vi) Direct loss of profit.

(vii) Breakdown maintenance practice cannot be employed for those plant items whic are regulated by statutory provisions, for example cranes, lifts, hoists and pressure vessels.



Corrective Maintenance Workflow

1.7.3 SCHEDULED MAINTENANCE:

It refers to tasks such as inspections and repairs that are performed according to a pr defined maintenance schedule. These tasks can include isolated responses to work orders as well as periodic, recurring services such as machine lubrication.

Advantages of Scheduled Maintenance

Scheduled maintenance serves a variety of other purposes.

- Higher personnel utilization since maintenance workers spend more time work
- Increased asset life expectancy as breakdowns are prevented
- Lower maintenance costs as time is utilized efficiently and costly problems are prevented
- Culture of proactive efficiency as personnel perform needed tasks
- Reduced liability as assets is kept in safe working condition

EXAMPLESScheduled maintenance includes inspections, adjustments, regular service, and planned shutdowns, lubrication, servicing, etc., of these equipment are included in the predetermined schedule. Scheduled maintenance practice is generally followed for overhauling of machines, cleaning of water and other tanks, white-washing of buildings, etc..

An example of scheduled maintenance recurring at repeating intervals is changing a bearing on a conveyor belt every 30 days or inspecting the condition of a motor every 9 days. Scheduled maintenance can also take the form of a one-time work order. If a problem with an asset or part is identified, a time is scheduled to check and repair the asset.

1.7.4 PREVENTIVE MAINTENANCE

A system of scheduled, planned or preventive maintenance tries to minimize the problems of breakdown maintenance. It is a stich-in-time procedure. It locates weak spots (such as bearing surfaces, parts under excessive vibrations, etc.) in all equipment, provides them regular inspection and minor repairs thereby reducing the danger of unanticipated breakdown. The underlying principle of preventive maintenance is that prevention is better than cure.

Objectives of Preventive Maintenance:

- To minimize the possibility of unanticipated production interruption or major breakdown by locating or uncovering any condition which may lead to it.

- To make plant equipment and machinery always available and ready for use.
- To maintain the value of equipment and machinery by periodic inspections, repairs, overhauls, etc.
- To maintain the optimum productive efficiency of the plant equipment and machinery.
- To maintain the operational accuracy of the plant equipment.
- To reduce the work content of maintenance jobs.
- To achieve maximum production at minimum repair cost.
- To ensure safety of life and limbs of the workmen

Advantages

Preventive maintenance offers several key advantages

1. Improved Safety Maintaining assets prevents potentially dangerous failure, mitigating against injury and any associated liability lawsuits.

2. Greater Equipment Lifespan By making sure equipment runs according to guidelines you will help improve the lifespan of the asset. Failing parts reduce the life of your equipment, resulting in expensive repair or replacement.

3. Improved Productivity Statistics show that poor maintenance can reduce a company's production capacity by 20%. By meeting maintenance requirements, you can prevent this fall in productivity as well as reduce downtime to enable greater efficiency and productivity.

4. Reduced Costs It is estimated that running a piece of equipment to failure can cost ten times as much as performing periodic maintenance. The expense comes as a result of unexpected downtimes and repairs. By understanding the maintenance requirements, you can schedule necessary repairs or part replacements at a suitable time, whether that can be achieved internally or requires an outside professional.

5. Reduced Energy Consumption Preventive Maintenance can also have an environmental benefit, since poorly maintained electrical assets tend to use more energy than those that are functioning correctly. Of course, there is also the financial benefit of lower energy bills as a result.

Disadvantages

While the advantages of preventive maintenance are clear, there are a few potential challenges associated with a PM schedule:

1. Budget Constraints Some smaller businesses have found that advanced digital maintenance solutions are expensive due to high price software and the cost of hiring external experts. Such budget issues have meant that some consider PM to be a luxury rather than a necessity. Fortunately, this situation has begun to change in recent years as more affordable options are entering the market.

2. Additional Resources Required Completing preventive maintenance may require more staff, parts and time. This requirement means that some companies will focus their preventive maintenance on essential, business-critical assets only.

3. Time-Consuming As mentioned above, PM can be time consuming. Inspection of complicated equipment can be a laborious task, which can lead some to try to skip some routine inspection and maintenance jobs.

4. Organisational Difficulties Organising your preventive maintenance can be difficult, especially if you have hundreds or thousands of assets to maintain. These difficulties are, however, greatly reduced through the use of a maintenance software program. A dedicated PM program cuts out the need for binders of paper and people remembering what should be done, and when.

Examples of Preventive Maintenance

Preventive maintenance requirements differ depending on the equipment being maintained. Example tasks may include cleaning, lubrication, replacing or repairing parts, or even partial or complete overhauls.

More obvious examples of preventive maintenance include ensuring production line equipment is working efficiently or heating, ventilation or air conditioning elements are inspected, cleaned and updated.

However, other areas in a business also require regular maintenance. Water supplies need to be sanitary, electrical systems have to be safe and compliant with legislation, and doors, lighting and flooring also needs to be checked to ensure they are all working correctly and not potentially hazardous.

Prepared By
Priyadarshini Mallick
(Lect, Math)

CHAPTER -02

OPERATION RESEARCH

Operation Research:Operations research (OR) is an analytical method of problem-solving and decision-making that is useful in the management of organizations. In operations research, problems are broken down into basic components and then solved in defined steps by mathematical analysis.

The process of operations research can be broadly broken down into the following steps:

1. Identifying a problem that needs to be solved.
2. Constructing a model around the problem that resembles the real world and variables.
3. Using the model to derive solutions to the problem.
4. Testing each solution on the model and analysing its success.
5. Implementing the solution to the actual problem.

Operations research includes statistical analysis, management science, game theory, optimization theory, artificial intelligence and network analysis. All of these techniques have the goal of solving complex problems and improving quantitative decisions.

Importance of Operation Research: - The field of operations research provides a more powerful approach to decision making than ordinary software and data analytics tools. Employing operations research professionals can help companies achieve more complete datasets, consider all available options, predict all possible outcomes and estimate risk. Additionally, operations research can be tailored to specific business processes or use cases to determine which techniques are most appropriate to solve

Some areas of management where O.R techniques have been successfully utilized are as follow:

1. Allocation and Distribution in Projects:

(i) Optimal allocation of resources such as men materials machines, time and money to projects.

(ii) Determination and deployment of proper workforce.

(iii) Project scheduling, monitoring and control.

2. Production and Facilities Planning:

(i) Factory size and location decision.

(ii) Estimation of number of facilities required.

(iii) Preparation of forecasts for the various inventory items and computation of economic order quantities and reorder levels.

(iv) Scheduling and sequencing of production runs by proper allocation of machines.

(v) Transportation loading and unloading,

(vi) Warehouse location decision.

(vii) Maintenance policy decisions.

3. Programmes Decisions:

(i) What, when and how to purchase to minimize procurement cost.

(ii) Bidding and replacement policies.

4. Marketing:

(i) Advertising budget allocation.

(ii) Product introduction timing.

(iii) Selection of advertising media.

(iv) Selection of product mix.

(v) Customer's preference of size, colour and packaging of various products.

5. Organization Behaviour:

(i) Selection of personnel, determination of retirement age and skills.

(ii) Recruitment policies and assignment of jobs.

(iii) Recruitment of employees.

(iv) Scheduling of training programs.

6. Finance:

(i) Capital requirements, cash flow analysis.

(ii) Credit policies, credit risks etc.

(iii) Investment decision.

(iv) Profit plan for the company.

7. Research and Development:

(i) Product introduction planning.

(ii) Control of R&D projects.

(iii) Determination of areas for research and development.

(iv) Selection of projects and preparation of their budgets.

(v) Reliability and control of development projects thus it may be concluded that operation research can be widely utilized in management decisions and can also be used as corrective measure

Methodology of Operation Research:

1. Formulating the Problem:
2. Constructing a Model to Represent the System under Study:
3. Deriving Solution from the Model:
4. Testing the Model and the Solution Derived from it:
5. Establishing Controls over the Solution:
6. Implementation of the Solution:

Methods for Solving Operation Research

The methods are: 1. Linear Programming 2. Transportation Problems 3. Waiting Line or Queuing Theory 4. Game Theory 5. Simulation and Monte Carlo Technique 6. Dynamic Programming.

METHOD 1. LINEAR PROGRAMMING:

- Linear programming, mathematical modelling technique in which a linear function is maximized or minimized when subjected to various constraints.
- By using linear programming technique, a production manager can allocate the limited amount of machine time, labour hours and raw material available with him to the different activities so as to maximise the output.

Linear programming may be defined as the problem of maximizing or minimizing a linear function which is subjected to linear constraints. The constraints may be equalities or inequalities. The optimisation problems involve the calculation of profit and loss. Linear programming problems are important class of optimisation problems, that helps to find the feasible region and optimise the solution in order to have the highest or lowest value of the function.

Linear programming is the method of considering different inequalities relevant to a situation and calculating the best value that is required to be obtained in those conditions.

Some of the assumption taken while working with linear programming are:

- The number of constraints should be expressed in the quantitative terms
- The relationship between the constraints and the objective function should be linear
- The linear function (i.e., objective function) is to be optimised

Components of Linear Programming

The basic components of the LP are as follows:

- Decision Variables
- Constraints
- Data
- Objective Functions

Characteristics of Linear Programming

The following are the five characteristics of the linear programming problem:

Constraints – The limitations should be expressed in the mathematical form, regarding the resource.

Objective Function – In a problem, the objective function should be specified in a quantitative way.

Linearity – The relationship between two or more variables in the function must be linear. It means that the degree of the variable is one.

Non-negativity – The variable value should be positive or zero. It should not be a negative value.

Decision Variables – The decision variable will decide the output. It gives the ultimate solution of the problem. For any problem, the first step is to identify the decision variables.

MethodsFor Solving Linear Programming:

There are several methods to solve linear programming problems such as graphical, index distribution, simplex and modified distribution methods. But the graphical method is quite easy and simple. The other method commonly used is simplex method.

Example: Consider a chocolate manufacturing company that produces only two types of chocolate – A and B. Both the chocolates require Milk and Choco only. To manufacture each unit of A and B, the following quantities are required:

- Each unit of A requires 1 unit of Milk and 3 units of Choco
- Each unit of B requires 1 unit of Milk and 2 units of Choco

The company kitchen has a total of 5 units of Milk and 12 units of Choco. On each sale, the company makes a profit of

- Rs 6 per unit A sold
- Rs 5 per unit B sold.

Now, the company wishes to maximize its profit. How many units of A and B should it produce respectively?

Solution: The first thing do is represent the problem in a tabular form for better understanding.

	Milk	Choco	Profit per unit
A	1	3	Rs 6
B	1	2	Rs 5
Total	5	12	

Let the total number of units produced by A be = X

Let the total number of units produced by B be = Y

Now, the total profit is represented by Z

The total profit the company makes is given by the total number of units of A and B produced multiplied by its per-unit profit of Rs 6 and Rs 5 respectively.

Profit: Max Z = 6X+5Ywhich means we have to maximize Z.

The company will try to produce as many units of A and B to maximize the profit. But the resources Milk and Choco are available in a limited amount.

As per the above table, each unit of A and B requires 1 unit of Milk. The total amount of Milk available is 5 units. To represent this mathematically,

$$X+Y \leq 5$$

Also, each unit of A and B requires 3 units & 2 units of Choco respectively. The total amount of Choco available is 12 units. To represent this mathematically,

$$3X+2Y \leq 12$$

Also, the values for units of A can only be integers.

So we have two more constraints, $X \geq 0$ & $Y \geq 0$

For the company to make maximum profit, the above inequalities have to be satisfied.

LPP FORMULATION

The Graphical Method

A linear program can be solved by multiple methods. In this section, we are going to look at the Graphical method for solving a linear program. This method is used to solve a two-variable linear program. If you have only two decision variables, you should use the graphical method to find the optimal solution.

A graphical method involves formulating a set of linear inequalities subject to the constraints. Then the inequalities are plotted on an X-Y plane. Once we have plotted all the inequalities on a graph the intersecting region gives us a feasible region. The feasible region explains what all values our model can take. And it also gives us the optimal solution.

Step 1: Formulate the LP (Linear programming) problem

Step 2: Construct a graph and plot the constraint lines

Step 3: Determine the valid side of each constraint line

Step 4: Identify the feasible solution region

Step 5: Plot the objective function on the graph

Step 6: Find the optimum point

Q. Maximize and minimize z = 4x + y subject to:- Hence, maximum value of Z is 120 at the point (30, 0) and the minimum value of z is 0 at the point (0, 0). x + y ≤50 3x + y ≤90 x ≥ 0, y ≥ 0 A. The constraint lines are x + y = 50, 3x + y = 90, x = 0, y = 0 10 10 20 20 30 40 40 50 60 60 70 70 80 90 100 3x + y = 90 C(0, 50) B(20, 30) (50, 0) A (30, 0) x + y = 50 YI Y XI 0 X

Example: A farmer has recently acquired a 110 hectares piece of land. He has decided to grow Wheat and barley on that land. Due to the quality of the sun and the region's excellent climate, the entire production of Wheat and Barley can be sold. He wants to know how to plant each variety in the 110 hectares, given the costs, net profits and labour requirements according to the data shown below:

Variety	Cost (Price/Hec)	Net Profit (Price/Hec)	Man-days/Hec
Wheat100	50	10	
Barley 200	120	30	

The farmer has a budget of US$10,000 and availability of 1,200 man-days during the planning horizon. Find the optimal solution and the optimal value.

Solution: To solve this problem, first we going to formulate our linear program.

Formulation of Linear Problem

Step 1: Identify the decision variables

The total area for growing Wheat = X (in hectares)

The total area for growing Barley = Y (in hectares)

X and Y are my decision variables.

Step 2: Write the objective function

Since the production from the entire land can be sold in the market. The farmer would want to maximize the profit for his total produce. We are given net profit for both Wheat and Barley. The farmer earns a net profit of US$50 for each hectare of Wheat and US$120 for each Barley.

Our objective function (given by Z) is, Max Z = 50X + 120Y

Step 3: Writing the constraints

Project Management:Project management is the discipline of planning and executing projects. Project management seeks to achieve defined goals by using plans, schedules and resources to execute project activities within a set timeframe.

Project:Project is a series of tasks that need to be completed to reach a specific outcome.

Network Technique:

- Network technique is a technique for planning, scheduling (programming) and controlling the progress of projects. This is very useful for projects which are complex in nature or where activities are subject to considerable degree of uncertainty in performance time.
- This technique provides an effective management, determines the project duration more accurately, identifies the activities which are critical at different stages of project completion to enable to pay more attention on these activities, analyse the scheduling at regular interval for taking corrective action well in advance, facilitates in optimistic resources utilisation.

Applications of Network Technique

Planning, Construction of buildings, bridges, highways, railways, stadiums, irrigation projects, factories, power projects etc. Assembly line scheduling,Development and launching of new products,Strategic and tactical military planning, Research and development,

Main advantages of the network system are as follows:

1. Detailed and thoughtful planning provides better analysis and logical thinking.
2. Identifies the critical activities and focus them to provide greater managerial attention.
3. Network technique enables to forecast project duration more accurately.
4. It is a powerful tool for optimisation of resources by using the concept of slack.
5. It provides a scientific basis for monitoring, review and control, to evaluate effect of slippages.
6. It helps in taking decision;

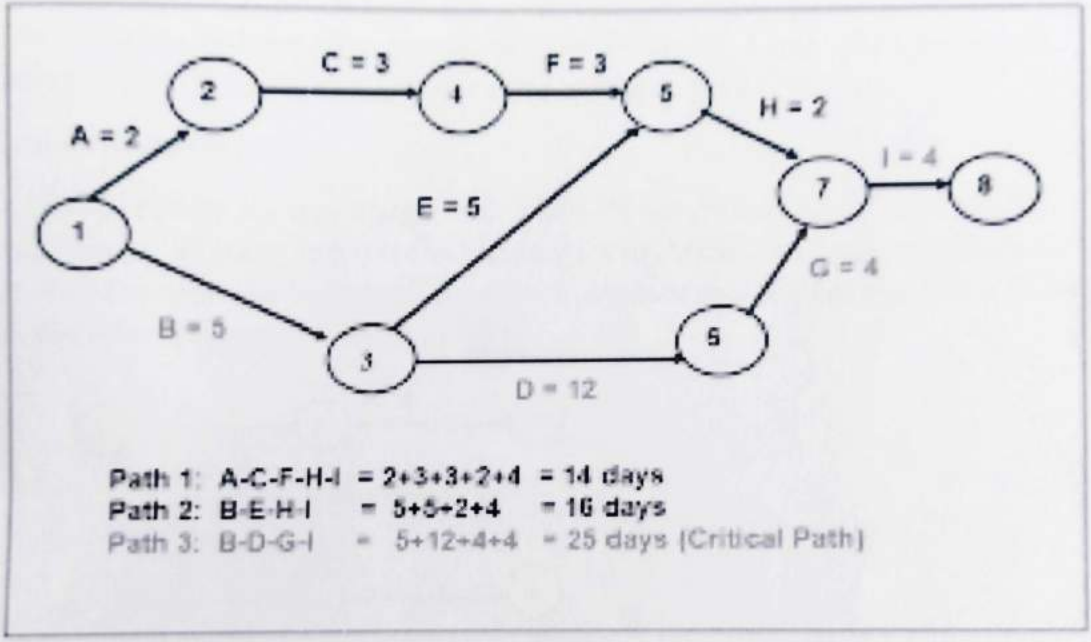
Limitations of Network Techniques:

Network techniques have following limitations:

(i) Network technique is simply a tool to help the management; hence its effectiveness depends on how well it is used by the management.

(ii) Its accuracy depends on the estimation of the data used in the network.

(iii) It is useful only if it is updated regularly and decisions for corrective actions are taken timely.



Path 1: A-C-F-H-I = 2+3+3+2+4 = 14 days
Path 2: B-E-H-I = 5+5+2+4 = 16 days
Path 3: B-D-G-I = 5+12+4+4 = 25 days (Critical Path)

Terms In Network Analysis

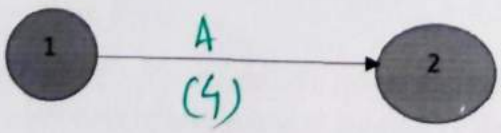
Event

An **event** is a specific instant of time, which makes the start or end of an **activity**. **Event** consumes neither time nor resources. An event is represented as node with numerical in network diagram.

Activity

An **activity** is the actual performance of the **task** and requires time and resources for its completion. An activity is represented as arrow .

A (4)



Activities are classified as below

(a)Critical Activity:

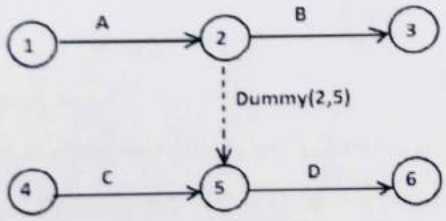
Critical activities are the project tasks that must start and finish on time to ensure that the project ends on schedule. A delay in any critical path activity will delay completion of the project, unless the project plan can be adjusted so that successor tasks finish more quickly than planned. A critical activity may be marked as thick arrow or double arrow.

(b)Non-Critical Activity:

The activities which consume more time than the specified time , then the project duration will not be delayed known as Non-critical activities.

(c)Dummy Activity:

A Dummy activity is a type of operation in project network which neither requires any time nor any resource. It is an imaginary activity shown in a project network to identify the dependence among operation. Byconvention dummies are always shown as dotted arcs in network diagrams.



(d)Predecessor activity

The activity proceeding to any given activity is called the predecessor activity.

(e)Successor activity

The activity succeeding to any given activity is called the successor activity.

Duration:

Duration is the estimated or actual time required to complete a task or an activity.

Total Project Time:

The time required to complete a project. It is also the duration of critical path.

Earliest start time (EST)

It is defined as the earliest possible time at which an activity can start. It is calculated by moving from first to last event in a network diagram.

Earliest finish time (EFT) It is the earliest possible time at which an activity can finish.

EFT = EST + duration of that activity.

Latest finish time (LFT) It is calculated by moving from last event to the first event of the network diagram.

Latest start time It is the latest possible time by which an activity can start.

LST = LFT – duration of that activity.

Float or Slack

Stack is with reference to an event and float is with reference to an activity. It means spare time or a margin of extra time over and above its duration which a non critical activity can consume without delaying the project.

Float is the difference between time available for completing an activity and the timenecessary to complete an activity.

(a)Total Float It is the time span by which the starting and finishing an activity can be delayed without delaying the completion of the project. It is the additional time, which a non critical activity can consume without increasing the project duration.

TF=LST-EST or LFT-EFT

(b)FreeFloat:

If all non critical activities start as early as possible ,the surplus time is free float.

FF= EST of tail event -EST of head event- duration of activity

(c)Independent Float:

Independent float is that portion of the total float within which an activity can be delayed for start without affecting the float of the preceding activities. If IF value is negative then taken it as zero

IF = EST of tail event - LFT of head event - activity

Critical path It is the sequence of critical activities, which decide the total project duration. A critical path consumes maximum resources. It is the longest path and consumes maximum time. It is the one, which connects the events having zero float.

Network Diagram: It is basic feature of network planning and represents all events and activities in sequence.

Fulkerson's Rule for Numbering the Events

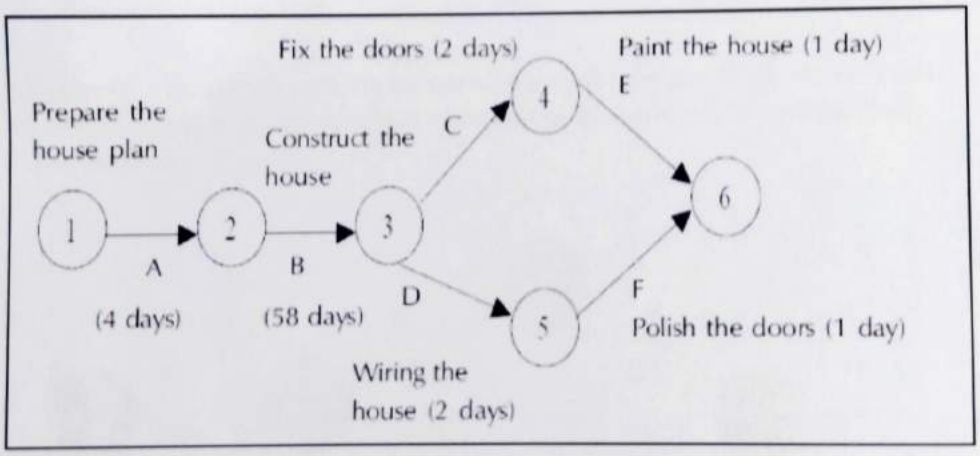
1. Event a is the starting or initial event; hence number it as 1
2. From event 1, strike off all outgoing activities. This would have made one or more events as initial events (event which do not have incoming activities).Number that event as 2.

3. Repeat step 2 for event 2, event 3 and till the end event. The end event must have the highest number.

Example:

Name of the activity	Starting and finishing event	Description of activity	Predecessor	Time duration (days)
A	(1,2)	Prepare the house plan	--	4
B	(2,3)	Construct the house	A	58
C	(3,4)	Fix the door / windows	B	2
D	(3,5)	Wiring the house	B	2
E	(4,6)	Paint the house	C	1
F	(5,6)	Polish the doors / windows	D	1

Solution:



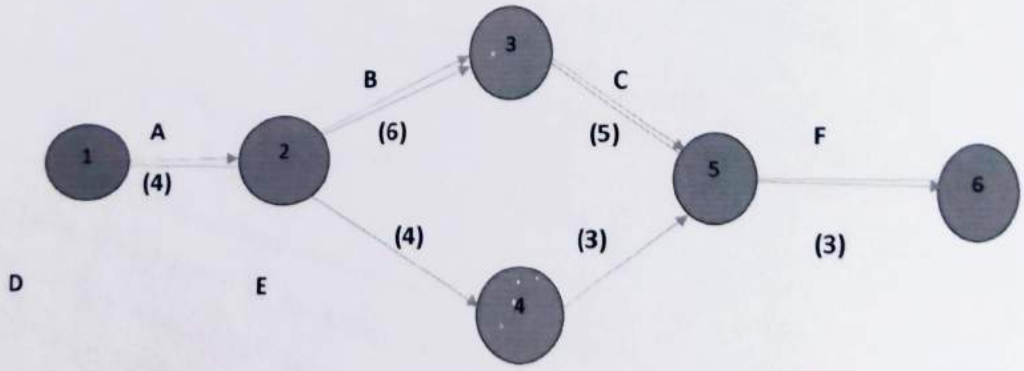
Example-2

The following details are available regarding a project:

Activity	Predecessor activity	Duration(days)
A		4
B	A	6
C	A	5
D	B	4
E	C	3
F	D,E	3

Determine the critical path, the critical activities and the project completion time.

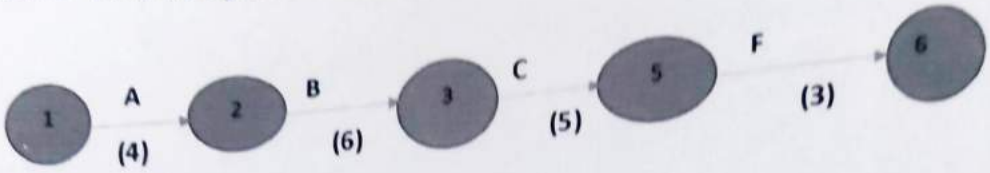
SolutionFirst let us construct the network diagram for the given project. We mark the time estimates along the arrows representing the activities. We obtain the following diagram:



Network Diagram

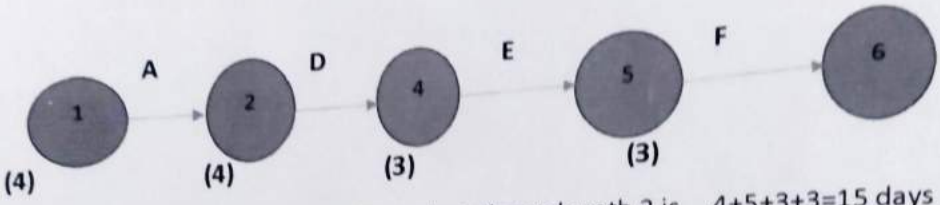
Consider the paths, beginning with the start node and stopping with the end node. There are two such paths for the given project. They are as follows:

Path -1 From the figure the first path is A-B-C-F



Time requires to complete the project through path 1 is 4+6+4+3=17 days

Path-2 From the figure the second path is A-D-E-F



The time requires to complete the project through path 2 is 4+5+3+3=15 days

Compare the times for the two paths. Maximum of {17,15} = 17

We see that path I has the maximum time of 17 days. Therefore, path I is the critical path. The critical activities are A, B, D and F. The project completion time is 17 days.

From Example-2 Also calculate EST EFT LST LFT of the project

Solution: EST is calculated by moving forwardstarting from event-1 or Activity A

Activity-A **Earliest Start Time (EST)for Activity A is 0 (zero)**

Activity-B **$EST_B = EST_A$ + Duration of A = 0 + 4 = 4**

Activity-C **$EST_C = EST_B$ + Duration of B = 4 + 6 = 10**

Activity-D **$EST_D = EST_A$ + Duration of A = 0 + 4= 4**

Activity-E **$EST_E = EST_D$ + Duration of D = 4 + 4= 8**

Activity F As Activity F depends upon two paths (1 &2) , So we have to compare the EST of two path and consider the Maximum vale of

Chapter - 07
Inspection and Quality Control

7.1 Definition of Inspection & Quality Control :-

Inspection :- An item or product which is manufactured, is required to perform certain functions. The act of checking wether a component actually does so or not is called inspection.

→ In other words, Inspection means checking the acceptability of manufactured product.

→ Inspection measures the qualities of a product or service in terms of ~~product~~ predecided standards.

Objective of Inspection :-

(i) Inspection separates defective components from non-detective ones and thus ensures the adequate quality of products.

(ii) Inspection locates defects in raw materials and flaws in processes which otherwise cause problems at the final stage. For example, detecting the parts not having proper tolerances during processing itself, will minimize the troubles arising at the time of assembly.

(iii) Inspection prevents further working being done on semi-finished products already defected as spoiled.

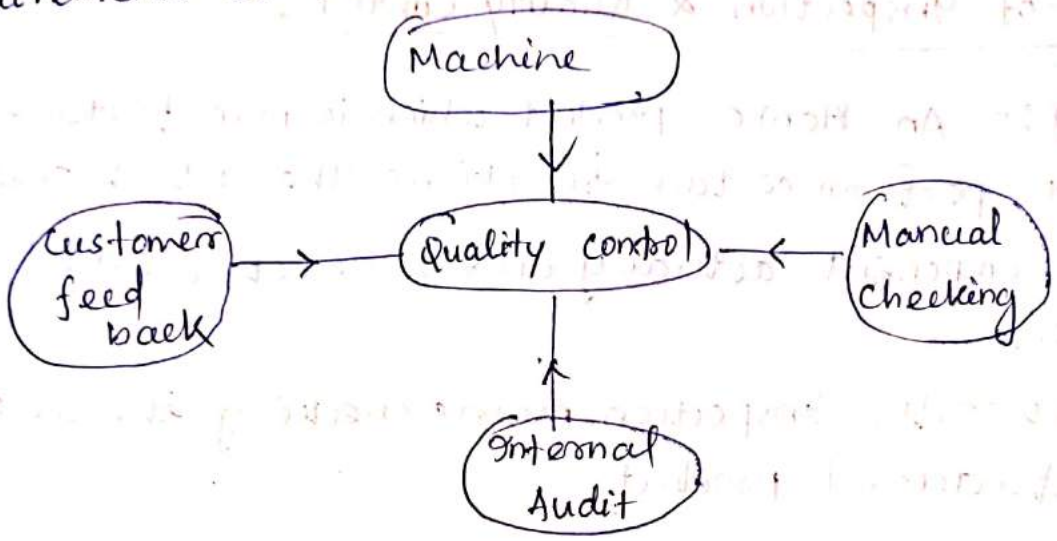
(iv) Inspection makes sure that the product works and it works without hurting anybody i.e its operation is safe.

(v) Inspection detects sources of weakness and trouble in the finished products and thus checks the work of designers.

(vi) Inspection buils up the reputation of the concern as it helps reducing the number of complaints from the customers.

Quality Control :-

- Quality control 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 clinet or customer.



Objective of Quality Control :-

(i) Improvement of quality of products
(ii) Reduction of scrap and rework
(iii) Efficient use of man and machines
(iv) Decreased inspection costs
(v) Scientific evaluation of quality and production.
(vi) Quality caution at all levels
(vii) To decide about the standards of quality of a product that is easily acceptable to the customer.
(viii) To check the variation during manufacturing
(ix) To prevent the poor quality product reaching to customer

Types of Inspection :-

(a) Roving or patrolling or floor inspection
(b) Fixed inspection
(c) Key point Inspection
(d) Final Inspection

(a) Roving or Patrolling or Floor Inspection :-

- The inspector walks round on the shop floor from machine to machine and checks samples of the work of various machine operators or workers.
- Floor inspection helps catching errors during process itself i.e before the final production is ready.
- → It is more effective and desirable because the work need not be transported to a centralized place.

(b) Fixed Inspection :-

- The work is brought at intervals for inspection to check
- Fixed inspection discovers defects after the job has been completed
- Fixed inspection is used when inspection equipments and tools cannot be brought on the shop floor.
- It is a sort of centralized inspection, the workers and the inspector do not come in contact with each other; thus it eliminates any chances of passing a doubtful product.

(c) Key point Ispection :-

- Every product has a key point in its process of manufacture A key point is a stage beyond which either the product requires an expensive operation or it may not be capable of rework
- Inspection at a key point segregates and thus avoids unnecessary further expenditure on poor and subsequent substandard parts which are likely to be rejected finally.

(d) Final Inspection :-

- The final inspection of the product may check its appearance and performance.
- Many destructive and nondestructive inspection and test methods such as tensile, fatigue, impact testing etc. and ultrasonic inspection, x-ray radiography, etc respectively are available for final inspection of the products manufactured.
- Final inspection is a centralized inspection and it makes use of special equipments.

Statistical Quality Control :- (SQC)

→ A quality control system performs inspection, testing and analysis to conclude whether the quality control when statistical techniques are employed to control quality or to solve quality control problems.

→ Statistical quality control makes inspection more reliable and at the same time less costly. It controls the quality level of the outgoing products.

Factors influencing the quality of manufacture :-

(i) Market :- Because of technology advancement, we could see many new products to satisfy customer wants.

- Market for the product must exist before quality of the product is emphasized by management. It is unless to talk about the quality when the market for the product is lacking e.g. there is no demand for woolen garment in the hot climate

(ii) Money :- Most important factor affecting the quality of a product is the money involved in the production itself.

- In the present day of tough and cut throat competition, companies are forced to invest a lot in maintaining the quality of products.

(iii) Materials :- To turn out a high quality product, the raw material involved in production process must be of high quality.
- Selection of proper materials to meet the desired tolerence
(iv) & limit is also an important consideration.

(iv) Management :- Quality control and maintenance programmes should have support from top management. If the management is quality consious rather than merely quality conscious, organisation can maintain adequate quality of products.

(v) Men / People :- People employed in production in designing the products must have knowledge and experience in their respective areas.

(vi) Machines and Methods :- To maintain high standards of quality companies are investing in new machines and following new ~~prod~~ procedures and methods these days.

Control Charts :-

- Control charts are based on statistical sampling theory, according to which an adequate sized sample drawn, at random, from a lot represents the lot.
- Control chart is a graphical presentation of the collected information. The information pertains to measured or otherwise judge quality characteristics of the items or the samples.
- A control chart detects variations in the processing and warns if there is any departure from the specified tolerance limits.

Advantages of Control Chart :-

- It indicates whether the process is in control or out of control.
- It determines the process variability & detects the unusual variations taking place in a project.
- It ensures the product quality level.

(iv) It provides information about the selection of process & setting of the tolerance limit

- It builds up the reputation of the organisation through customer satisfaction.

Types of Control charts :-

(i) $\bar{X}$ chart
(ii) R chart
} variables or measurement chart

(iii) P chart
(iv) C chart
} Attribute chart

(i) $\bar{X}$ Chart :-

- It shows changes in process average and is affected by changes in process variability.
- It is a chart for the measure of central tendency.
- It shows erratic or cyclic shifts in the process.
- It detects steady progress changes like tool wear.
- It is the most commonly used variables chart.

(ii) R Chart :-

- It controls general variability of the process and is affected by changes in process variability.
- It is a chart for measure of spread.
- It is generally used along with an $\bar{x}$ chart.

Plotting of $\bar{x}$ & R chart :-

A good number of samples of items coming out of the machine are collected at random at different ~~time~~ intervals of time and their quality characteristics are measured.

- For each sample, the mean value and range is found out. For example if a sample contain 5 items, whose diameters are d_1, d_2, d_3, d_4 & d_5 the sample average.

$$\bar{X} = \frac{d_1+d_2+d_3+d_4+d_5}{5}$$

And, range R = Maximum diameter − Minimum diameter

A number of samples are selected and their average values and range are tabulated.

Example:

Sample No. (sample size-5)	$\bar{X}$	R
1	7.0	2
2	7.5	3
3	8.0	2
4	10.0	2
5	9.5	3
6	11.0	4
7	11.5	3
8	4.0	2
9	3.5	3
10	4.0	2
	$\Sigma\bar{X} = 76$	$\Sigma R = 26$

Average of $\bar{X}$, $\bar{\bar{X}} = \frac{\Sigma\bar{X}}{\text{No. of samples}}$

Average of R, $\bar{R} = \frac{\Sigma R}{\text{No. of samples}}$

Therefore, $\bar{\bar{X}} = \frac{76}{10} = 7.6$

$\bar{R} = \frac{26}{10} = 2.6$

For $\bar{X}$ chart; Upper control limit (UCL) $= \bar{\bar{X}} + A_2\bar{R}$

Lower control limit (LCL) $= \bar{\bar{X}} - A_2\bar{R}$

For R chart; Upper control limit, UCL $= D_4\bar{R}$

Lower control limit, LCL $= D_3\bar{R}$

The values of various factors (like A_2, D_4 & D_3) based on Normal distribution can be found from the following table

Sample size	A_2 Limit Average	D_3 Range lower limit	D_4 Range upper limit
2	1.88	0	3.27
3	1.02	0	2.57
4	0.73	0	2.28
5	0.58	0	2.11
6	0.48	0	2.00
8	0.37	0.14	1.86
10	0.31	0.22	1.78
12	0.27	0.28	1.72

→ Values of A_2, D_3 and D_4 for sample size 7, 9 & 11 can be determined by taking the mean value of sample sizes 6 & 8, 8 & 10 and 11 & 12 respectively.

→ Sample size in this problem is 5, therefore $A_2 = 0.58$,
$D_3 = 0$
$D_4 = 2.11$

Thus for $\bar{x}$ chart; Upper control limit, $UCL = \bar{\bar{x}} + A_2\bar{R}$

$= 7.6 + (0.58 \times 2.6)$

$= 7.6 + 1.51$

$= 9.11$

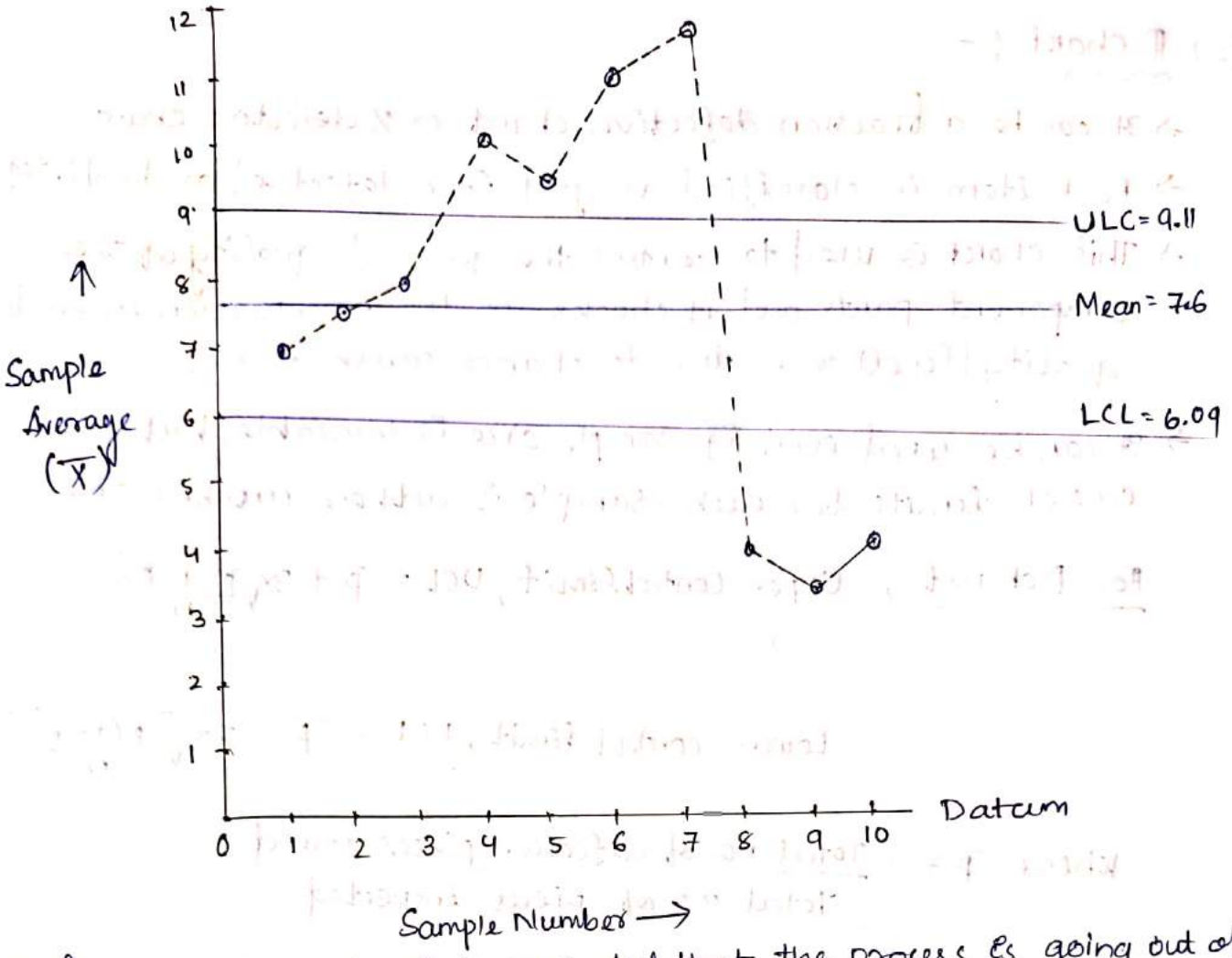
Lower control limit, $LCL = \bar{\bar{x}} - A_2\bar{R}$

$= 7.6 - 0.58 \times 2.6$

$= 6.09$

For R chart; $UCL = 2.11 \times 2.6 = 5.48$

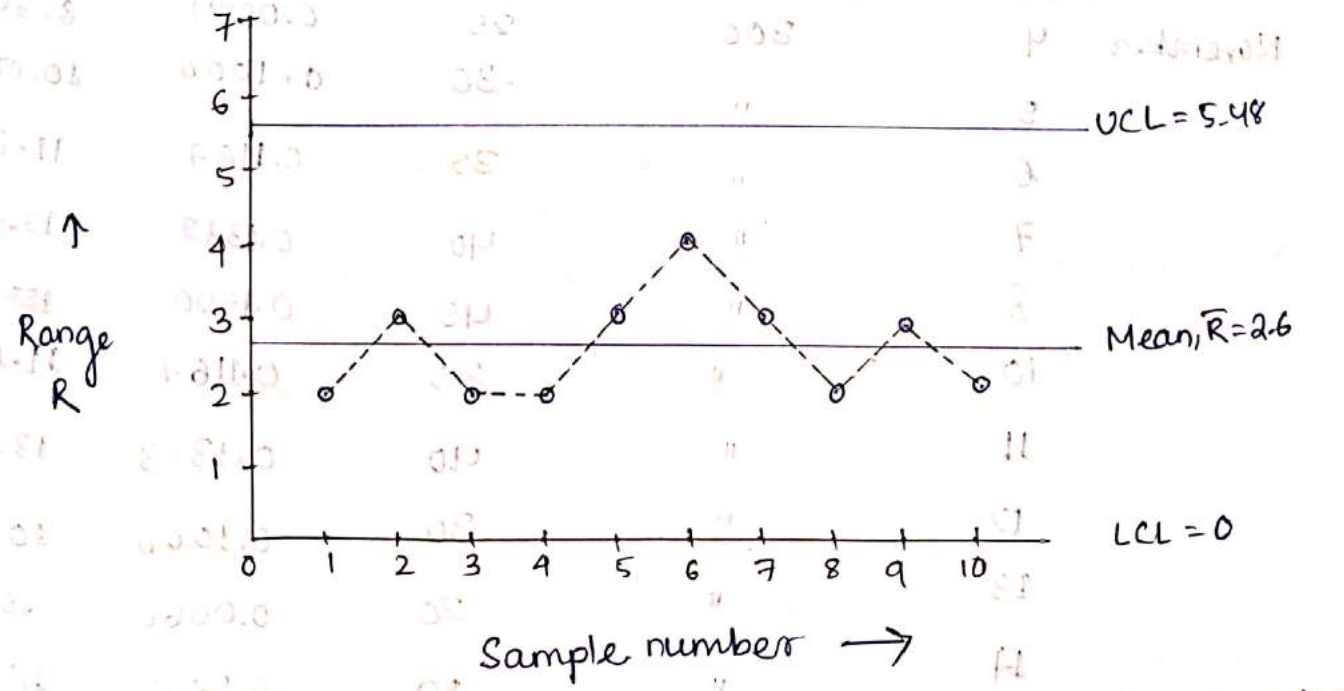
$LCL = D_3 \times \bar{R} = 0 \times \bar{R} = 0$



So from the $\bar{x}$ chart, it is concluded that the process is going out of control from the 4th sample onwards.

For R chart :- $UCL = D_4\bar{R} = 2.4 \times 2.6 = 6.48$ $\bar{R}$ = Mean = 2.6

$LCL = D_3\bar{R} = 0 \times 2.6 = 0$



→ From the R-chart it is concluded that all the range values are under control

(c) P chart :-

→ It can be a fraction defective chart or % defective chart

→ Each item is classified as good (non defective) or bad (defective)

→ This chart is used to control the general quality of the component parts and it checks if the fluctuation in product quality (level) are due to chance cause alone.

→ It can be used even if sample size is variable, but calculating control limits for each sample is rather cumbersome.

For P chart, Upper Control limit, $UCL = \bar{P} + 3\sqrt{\frac{\bar{P}(1-\bar{P})}{n}}$

Lower control limit, $LCL = \bar{P} - 3\sqrt{\frac{\bar{P}(1-\bar{P})}{n}}$

Where $\bar{P} = \frac{\text{Total no. of defective pieces found}}{\text{Total no. of pieces inspected}}$

Example

Date	Number of pieces inspected (a)	Number of defective pieces found (b)	Fraction defective P = (b)/(a)	% defective 100p
November 4	300	25	0.0834	8.34
5	"	30	0.1000	10.00
6	"	35	0.1167	11.67
7	"	40	0.1333	13.33
8	"	45	0.1500	15.00
10	"	35	0.1167	11.67
11	"	40	0.1333	13.33
12	"	30	0.1000	10.00
13	"	20	0.0666	06.66
14	"	50	0.1666	16.66
Total number of days = 10	Total = 3000	Total = 350		

For P-chart upper control limit, $UCL = \bar{p} + 3\times\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$

Lower control limit, $LCL = \bar{p} - 3\times\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$

$\because \bar{p} = \frac{\text{Total no. of defective pieces found}}{\text{Total no. of pieces inspected}} = \frac{350}{3000} = 0.1167$

And n = number of pieces inspected every day = 300

Therefore, $UCL = \bar{p} + 3\times\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$

$= 0.1167 + 3\times\sqrt{\frac{0.1167(1-0.1167)}{300}}$

$= 0.1167 + 3\times 0.01852$

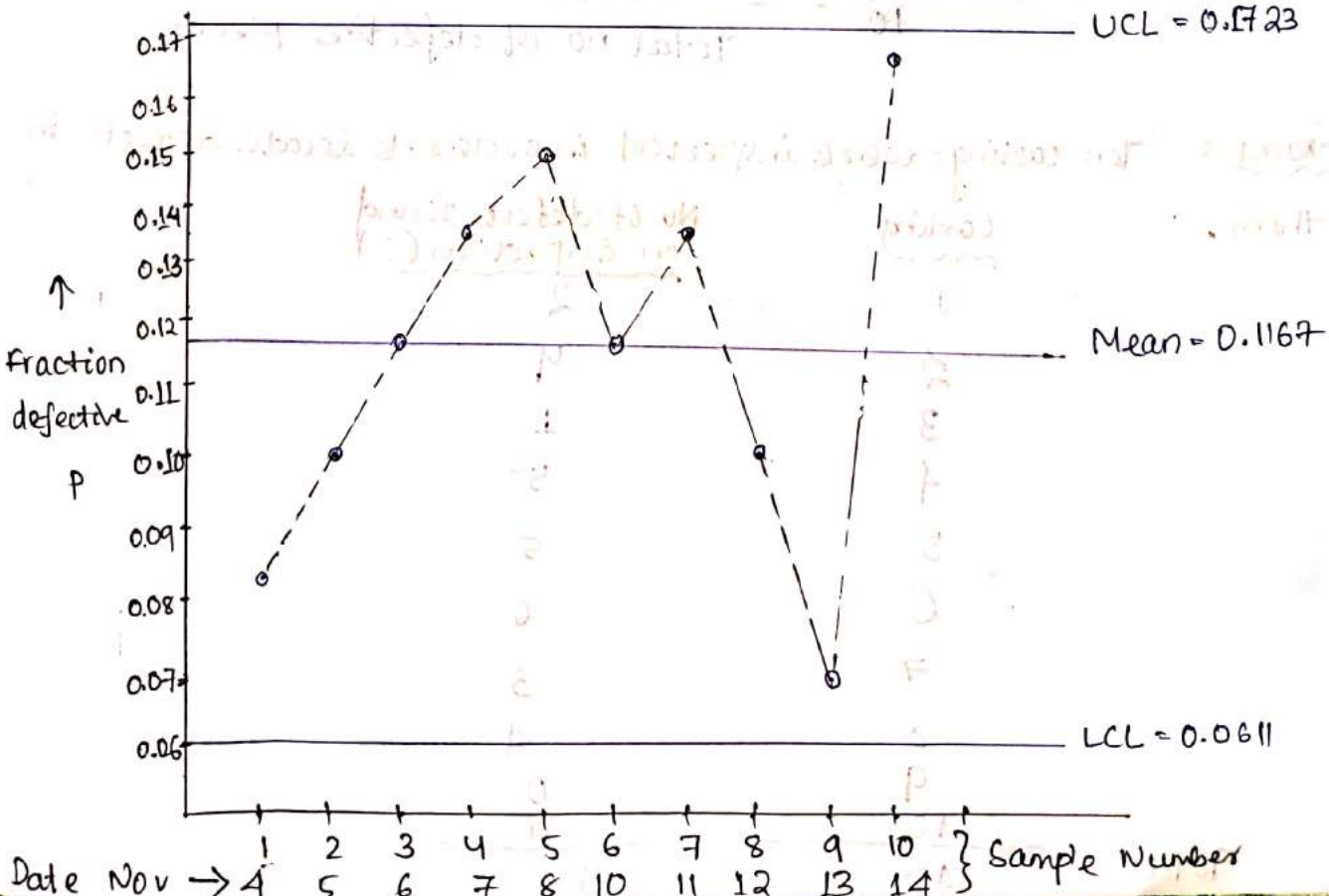
$= 0.17226 \approx 0.1723$ (Approximate)

$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$

$= 0.1167 - 3\sqrt{\frac{0.1167(1-0.1167)}{300}}$

$= 0.1167 - 3\times 0.01852$

$= 0.06114 \approx 0.0611$ (Approx)



9t can be visualised that all the points lie within the control limit and hence the process.

(d) C - Chart

1. 9t is the control chart in which number of defects in a piece or sample are plotted.
2. 9t controls number of defects observed per unit or per sample.
3. Sample size is constant
4. The chart is used where average number of defects are much less than the number of defects which would occur otherwise if everything possible goes wrong.
5. The C chart is preferred for large and complex parts

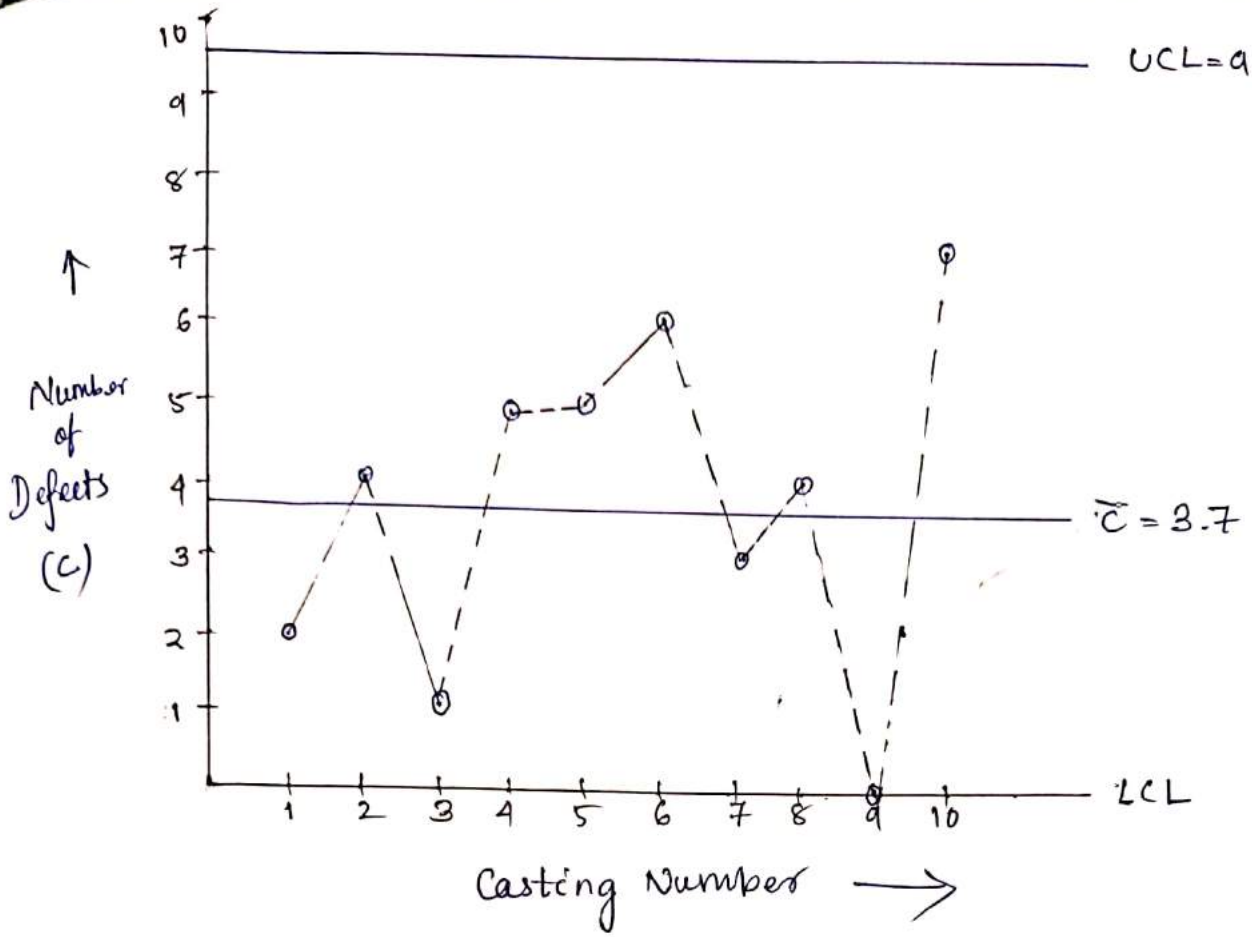
* Upper control limit, $UCL = \bar{c} + 3\sqrt{\bar{c}}$

Lower control limit, $LCL = \bar{c} - 3\sqrt{\bar{c}}$

Where $\bar{c} = \frac{37}{10} = \frac{\text{Total No. of defects found on inspection}}{\text{Total no. of defective pieces}}$

Example Ten castings were inspected in order to locate defects in them.

Casting	No. of defects found on inspection (C)
1	2
2	4
3	1
4	5
5	5
6	6
7	3
8	4
9	0
10	7
Total 10	37



Therefore, $\bar{c} = \frac{\text{Total no. of defects found on inspection}}{\text{Total no. of defective pieces}}$

$= \frac{37}{10} = 3.7$ (Mean)

Upper control limit, $UCL = \bar{c} + 3\sqrt{\bar{c}} = 3.7 + 3\sqrt{3.7} = 9.472$

Lower control limit, $LCL = \bar{c} - 3\sqrt{\bar{c}} = 3.7 - 3\sqrt{3.7} = -2.072 \approx 0$

⇒ It is concluded that since all the values of 'c' lie with in the control limit and hence the process.

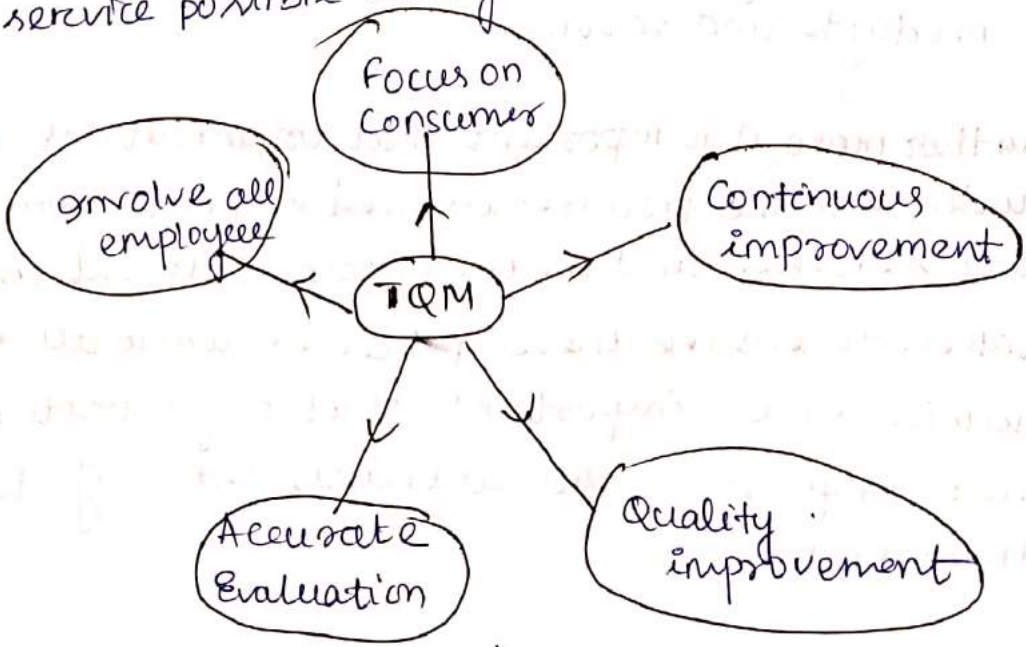
[∵ Lower control limit is negative & thus has been taken as zero]

Chapter-08 Contemporary Quality Management Concept

8.1 Total Quality Management (TQM)

Meaning and Definition :- Total Quality management provides the concept that ensures continuous improvement in an organisation.

- The philosophy of TQM stresses on a systematic, integrated and consistent approach involving everyone and everything in an organisation.
- It aims at using all people in multifunctional teams to bring about improvements from within the organisation. Everyone associated with the organisation is fully involved in continuous improvement.
- Total Quality management is an approach to improving the effectiveness and flexibility of business as a whole. It is essentially a way of organising and involving the whole organisation, every department every activity, every single person at every level.
- TQM is a strategic approach to produce the best product and service possible through constant innovation.



Principles of TQM :-

- With increased competion and market globalization, TQM principles and practices are now becoming more and more Important for the leadership and management of any organization.
- Therefore for organizations that seek to continually improve their performance over a long term, focus on customers and address the needs of all other stake-holders, these total quality management principles will serve as a guide in the right direction.

Principle -1 : Customer Focus

- This principle stresses that an organization should understand its customers; what they need and when they need it while trying to meet and exceed their expectations.
- A such, revenue is increased, and waste reduced when a business seeks opportunities to satisfy its customers.

Principle-2 Leadership

- Good leaders help to unite an organization and give people a sense of direction. They create and nurture an environment where everyone's views are given careful consideration.
- Therefore without clear leadership, an organization loses its direction.
- This principle establishes that leaders are ~~clear~~ fundamental in setting clear goals and objectives and ensuring that employees are actively involved in achieving these objectives.

Principle-3 People involvement :-

- People are the essence of any organization's existance.
- Research has shown that when people understand the importance of their contribution and role in an organization, they become innovative, eager to participate and creative in organization's objective.
- It helps to bridge the gap of communication between mangement & employees.

Principle-4 Process Approach

- This principle states that an organization achieves its desired result when related resources and activities are managed as a process.
- Therefore this approach stresses efficiency, effectiveness, consistency & understanding.

Principle-5 System Approach to management

This principle stresses that several processes are managed simultaneously in an ~~organization~~ organized system. This makes the system much more effective and greater than the sum of its individual parts.

Principle-6 Continuous improvement

This principle states that continual change should be an active business objective. By doing so, Organizational flexibility increased ability to embrace new opportunity & improved performance are achieved.

Concept of Total Quality Management

(i) Continuous improvement of Quality :-

- Foremost among TQM concepts is the idea of continuous improvement of quality.
- The underlying aim of TQM is to improve the quality of products and services in any organization. By so doing, productivity, employability and customer service are improved.

(ii) Focus on the customer :-

- The customers are the internal and external recipients of an organization's products.
- Therefore the needs of customers and their desires define quality for the organization.

(iii) Operations improvement

- Every work done in an organization follows a chain or process. These processes account for 80-85% of the quality of work and productivity of employees.
- This concept establishes that work progress and processes should be studied through individuals or teams, to identify complexities or lapses.

(iv) Human Resources :-

- These concepts of TQM are committed to employee learning & development. So these require that management trust that well-trained staff can do the jobs assigned to them properly.
- In addition, human resource development includes providing the training required in a quality improvement work environment as well as extensive education to help employees keep up-to-date on their jobs.

ISO 9000

- ISO 9000 is a family of standards and guidelines related to the Quality Management system (QMS). It sets the requirements for the assurance of quality and for the mangement's involvement.
- When an organization demonstrates conformity to ISO 9000 to an independent resistar fiom, the register can to certify the organization. Registration provides assurance to customers worldwide that products or services from the organization can be expected to consistently meet customer requirements.

- The ISO 9000 QMS is based on eight principles from Total quality management system.

(i) Customer focus :- Understanding the customer's needs, meet the customer's requirements & strive to exceed the customer expectation.

(ii) Leadership :- Establish unity of purpose and organizational direction and provide an environment that promotes employee involvement and achievement of objectives.

(iii) Involvement of People :- Take advantage of fully involved employees using all their abilities for the benifit of the organization.

(iv) Process Approach :- Recognize that things accomplished are the results of process and that processes along with related activities and resources must be managed.

(v) System Approach to Management :-

The multiple interrelated processes that contribute to the organization's effectiveness are system and should be managed as a system.

(vi) Continual Improvement :- Continual improvement should be a permanent objective applied to the organization and to its people, process, system and products.

(vii) ~~Factual~~ factual Approach to Decession making :-

Decisions a must be based on the analysis of accurate relevant and reliable data & information.

(viii) Mutually Beneficial Supplier Relationship :-

Both the organization and suppliers benefiting from one another's resources and knowledge results in value of for all.

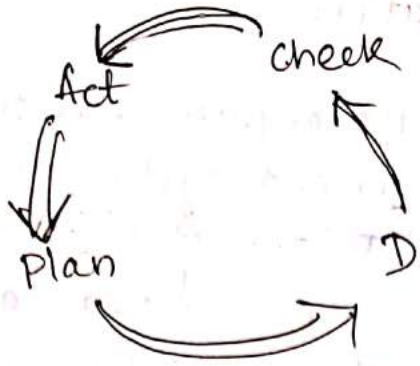
ISO 9000's Operating principle

(i) Plan :- Establish objective & develop the plans to achieve them

(ii) Do :- Put the plans in to action.

(iii) Check :- Measure the results of the action ; that is planned action working or were the objectives met

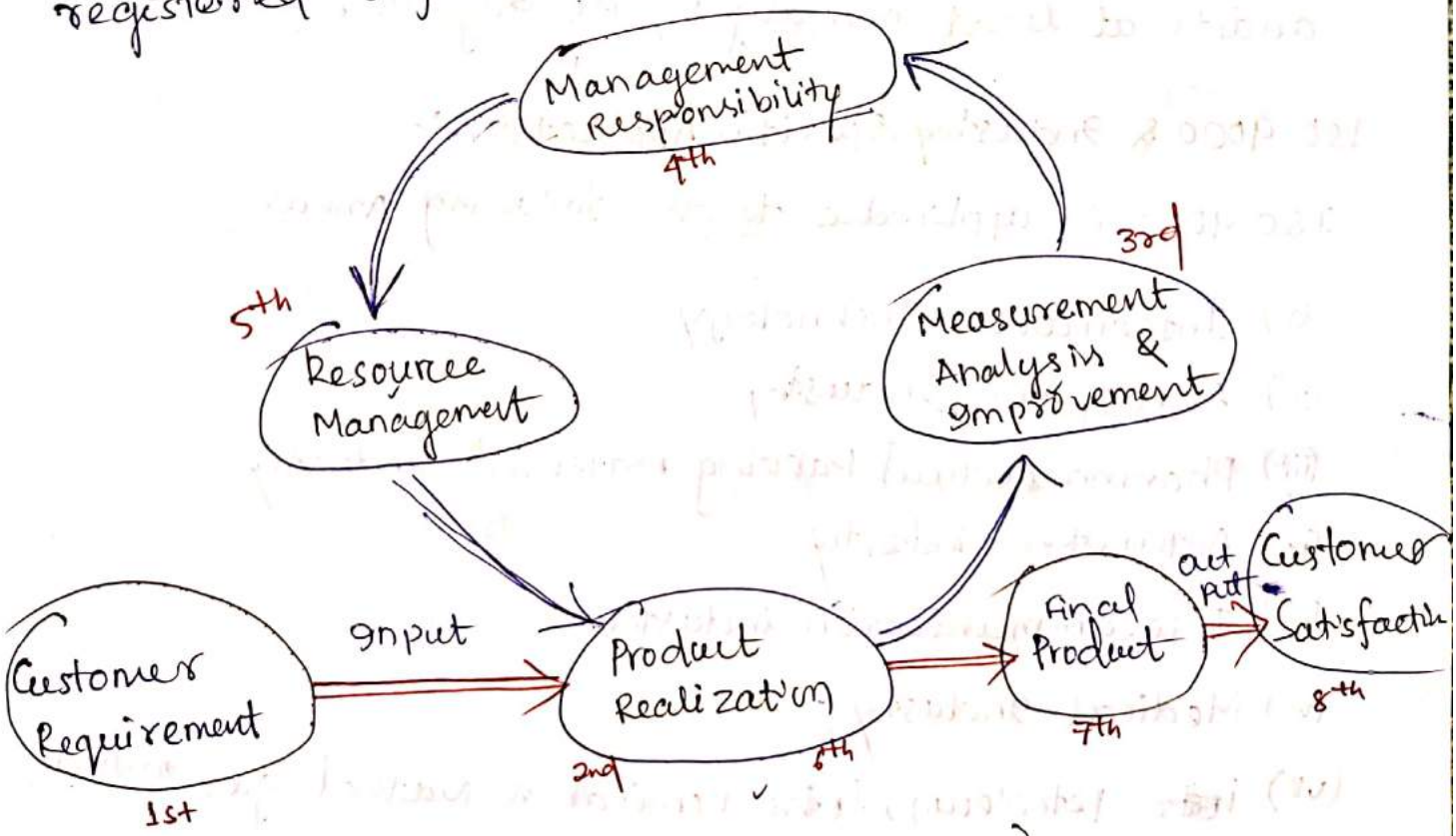
(iv) Act :- Learn from the results of the third (check step), make any necessary changes to the plans and ~~reapet~~ repeat the cycle.



(ISO 9000 operation prineiple)

2MD

- **Aim of ISO 9000** :- The original aim of ISO 9000 is to ensure that the product or services provided by registered organizations were consistenly fit for their intended purposes.
- The ISO 9000 raised the standard's aim to a new level i.e customer focus & continual improvement along with the other six quality management prineiples that have been incorporated into the standard, are intended to make registered organizations more competitive.



(Fig :- ISO 9000 process Approach)

ISO 9000 Applied to Organization

The ISO 9001 lay down the requirements for what an organization's Quality management system must do, The organization determines that for itself and if seeking registration, employs an accredited registar firm to verify its conformance to ISO 9001

- Once the organization registered, must apply to QMS (Quality management system) to its operations according to the standard and exactly as the QMS states.
- And is also continually assess the effectiveness of the QMS & make changes to improve it and conduct periodic internal QMS audit.
- Then it submit to external (3rd party) surveillance audits at least annualy by its registar.

ISO 9000 & Industry Specific Applications :-

ISO 9000 is applicabe to the following Areas

(i) Information Technology
(ii) Aerospace Industry
(iii) Pharmaceutical Packing Material Industry
(iv) Automotive industry
(v) Telecommunication industry
(vi) Medical Industry
(vii) Petroleum, Petrochemical & Natual gas Industry

ISO 14000 :-

- The designation "ISO 14000" is a general term referring to a family of standards concerned with environmental management
- This refers to what the organization does to :-
  * Minimize harmful effects on the environment caused by its activities and to achieve continual improvement of its environmental performance.
- It is applicable to any business or organization, regardless of size, location or income.
- ISO 14000 is also known as a "generic management system family of standards".
- Here the management system refers to the organizations structure for managing its processes or activities - that transform inputs of resources into products or services which meet the organization's objectives such as satisfying the customer's quality requirements, complying with regulations or meeting environmental objective.

ISO 14000's Operating Principle :-

- The ISO 14001 standard is based on the plan - Do - Check - Act - improvement cycle.
- It begens with the enviormental policy, which is followed by planning, implementation and operation. checking & corrective action & management review.
- Plan :- What you will do?
  DO :- According to the plan.
  Check :- to see if you did what you planned.

Act – change or improve the part of your plan or Do that did not give you the results you intended.

DO

- Resource, Roles, Responsibility & Accthority
- Competence, Training & Awareness
- Communication, Documentation
- Emergency preparedness
- Operational Control

Act

- Management Review
- Evaluate
- Continual Improvement

Check

- Monitoring & Measurement
- Evaluation of compliance
- Nonconformity, Corrective Action & Preventive Action
- Internal Audit

Plan

- Environmental Policy
- Environmental Aspects
- Legal and Other Requirmt
- Objective, Target & Programs

Evolution of ISO 14000

- ISO 14000 is a set of rules and standards created to help companies reduce industrial waste & environmental damage.
- the ISO 14000 ~~certified~~, series of standards was introduced in 1996 by the International Organization for Standardization (ISO) and most recently revised on in 2015.

- Overview of the ISO 14000 family of standards

ISO 14001 :- It is the world's most recognized framework for environmental management system (EMS) that helps organizations both to manage better the impact of their activities on the environment & to demonstrate sound environmental management.

* ISO 14001 : 2015 : Environmental Management systems Requirements with guidance for use.

- ISO 14004 : which complements ISO 14001 by providing additional guidance and useful explanations.

* ISO 14004 : 2016 :- ~~Envi~~ General guidelines on principles, systems and support technique.

* ISO 14005 : 2019 :- Guidelines for a flexible approach to a phased implementation.

- ISO 14007 : Determining environmental costs and Benefitits.
- ISO 14008 : Monetary valuation of environmental impacts from specific emissions and use of natural resources.
- ISO 14006 : 2011 :- Environmental management system guidelines for incorporating ecodesign.
- ISO 14009 : EMS guidelines for applying the ISO 14001 framework to environmental aspects and environmental condition by environmental topic areas.

Evolution of ISO 14000

- ISO 14000 is a set of rules and standards created to help companies reduce industrial waste & environmental damage.
- the ISO 14000 ~~certified~~, series of standards was introduced in 1996 by the International Organization for Standardization (ISO) and most recently revised on in 2015.

- Overview of the ISO 14000 family of standards

ISO 14001 :- It is the world's most recognized framework for environmental management system (EMS) that helps organizations both to manage better the impact of their activities on the environment & to demonstrate sound environmental management.

* ISO 14001 : 2015 : Environmental Management systems Requirements with guidance for use.

- ISO 14004 : which complements ISO 14001 by providing additional guidance and useful explanations.

* ISO 14004 : 2016 :- ~~Envi~~-General guidelines on principles, systems and support technique.

+ ISO 14005 : 2019 :- Guidelines for a flexible approach to a phased implementation.

- ISO 14007 : Determining environmental costs and Benefitits.
- ISO 14008 : Monetary valuation of environmental impacts from specific emissions and use of natural resources.
- ISO 14006 : 2011 :- Environmental management system guidelines for incorporating ecodesign.
- ISO 14009 : EMS guidelines for applying the ISO 14001 framework to environmental aspects and environmental condition by environmental topic areas.

ISO 14010 to ISO 14015 :- Environmental Auditing & Related Activities

ISO 14020 to ISO 14024 – Environmental labeling

ISO 14031 & ISO 14032 – Environmental performance Evaluation

ISO 14040 – ISO 14043 :- Life cycle Assessment

ISO 14050 – Terms & Conditions

ISO 14064 – Greeen house gas accounting & verification

Implication of ISO 14000

- The ISO 14001 standard provides specific requirements for an Environment Management system (EMS) and focuses on Environmental Protection.

- An effective ESM provides many benifits to the implementing organization, its customers and stakeholders and to regulators including :

  i- reduced environmental risk

  ii- Proactive environmental management

  iii) improved employee environmental awareness and performance.

  iv) increased operating efficiency and cost effectiveness

JIT (Just In Time)

The main focus of JIT is to identify and correct the obstacles in the production process. It shows the hidden problems of inventory.

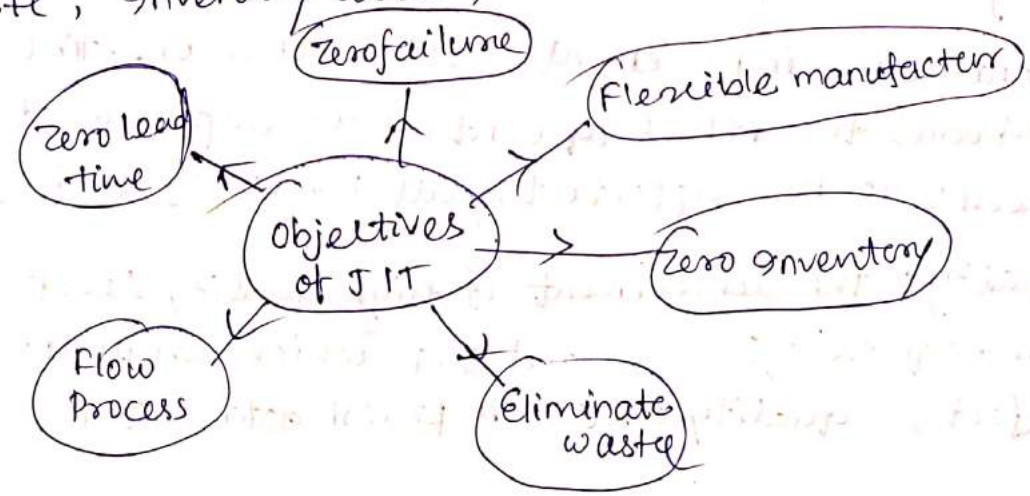
- JIT method prevents a company from using excessive inventory and smooth on production operations.
- JIT is a philosophy of manufacturing based on planned elimination of waste & continuous improvement of productivity.

History :- It is evolved in Japan after world war II as a result of their diminishing market share in the auto industry.

* Toyota motor company first to implement fully functional & successful JIT system in 1970's

Function of JIT :- Zero inventory
Zero lead time
Zero failure

* **Eliminating waste** :- There are 7 types of waste. waste from overproduction, waste of waiting time, transportation waste, inventory waste, waste from product defects.



JIT

Def^n of JIT :- The Just-in-time (JIT) inventory system is a management strategy that minimizes inventory & increases efficiency.

or In other words, JIT is an inventory management method where by materials, goods and labours are scheduled to arrive or be replenished exactly when needed in production process.

- JIT can be summarized as a system of eliminating waste and achieve excellence in an entire organization. The sole purpose of JIT is to eliminate waste.

Elements of JIT :-

(i) Automation & Autonomation :- means "to build in a mechanism to prevent mass production of defective work in machines or product lines." The autonomous machine ensures that 100% good units flow to the subsequent process in an uninterrupted manner.

(ii) Buffer stock Removal :- constant elimination of buffer stocks is emphasized to highlight production problems previously shielded by high inventory levels.

(iii) Computer integrated manufacturing :- The use of computers to automate manufacturing operations such as changing the type & ~~quadit~~ quantity of products through minimal changes

(iv) Continuous improvement :- JIT is not a one-time effort. It embodies the ethics of continuous improvement which needs to be supported by all levels of staff.

(v) Quality :- The achievement of high quality levels is a prerequisite of successful JIT which includes zero defects, quality circles & process data collection.

- Smooth Production :- Production smoothing enables the system to adapt smoothy to the variation in customer demand by gradually changing the frequency.

Benefits of JIT

- Improved competitive position,
  - " Worker efficiency
  - " equipment efficiency
- Increased flexibility
  - " teamwork
  - " profit margin
  - " quality & Productivity
- Less Scrap
- Lower overhead
- Reduce inventory & labour requirements.
  - " Production lead time.
- Closer Relationship with suppliers.

Disadvantages

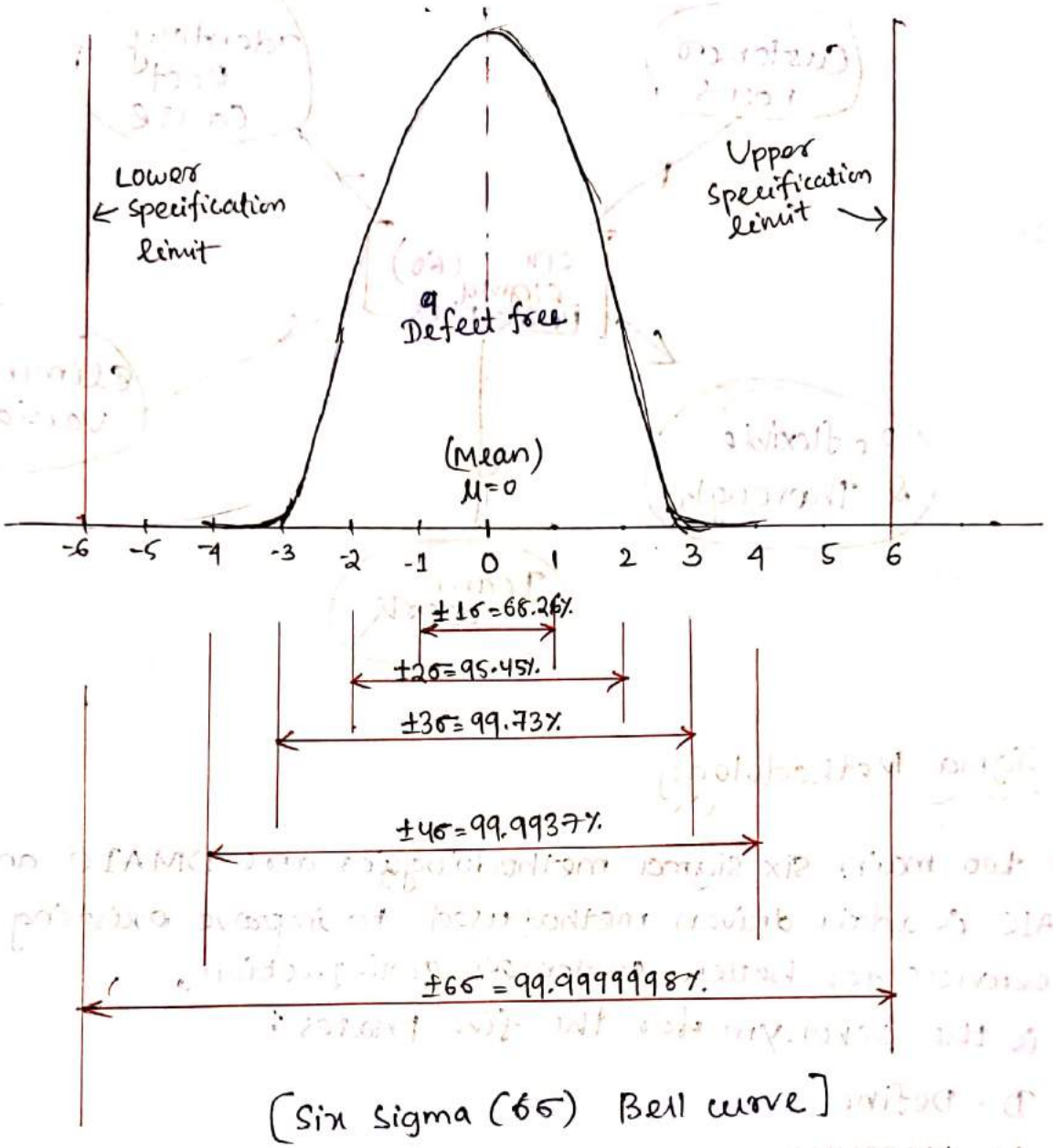
- Production may be stopped if suppliers are delayed
- Sales may be lost if not meeting customer demands
- Increased ordering & admin cost
- Depending on the efficiency of supplier.
- Less time for quality control on arrival of materials.

Six Sigma :- (6σ)

- Six sigma is a ~~deep~~ disciplined, statistical-based, data driven approach and continuous improvement methodology for eliminating defects in a product, process or service.
- It was developed by Motorola for the first time during 1980s.

- Sigma(σ) represents the population standard deviation which is a measure of the variation in a data set collected about the process.
  of a defect is defined by specification limits, separating good from bad outcomes of a process.
  mean (average) i.e six standard deviations from the nearest specification limit.

- Six sigma comes from the bell curve used in statistics where one sigma symbolizes a single standard deviation from the mean.
  of the process has six sigmas, three above and three below the mean, the defect rate is classified as "extremely low"



[Six Sigma (6σ) Bell curve]

Principles of Six Sigma

Six sigma success is based on five key ~~point~~ principles.

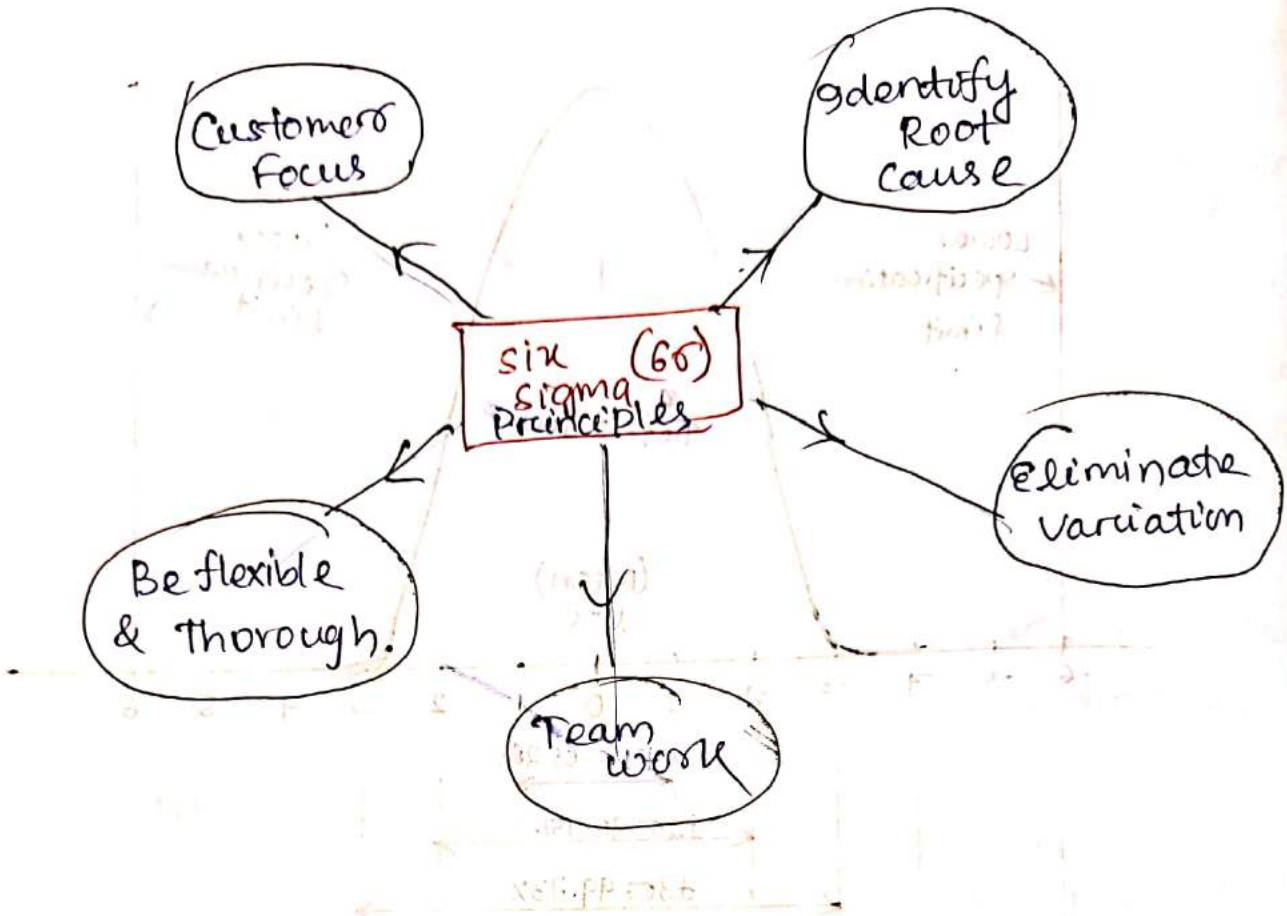
i- Focusing on customer requirements

ii- Using extensive measurement and statistical analysis to understand how work gets done and to identify the root cause of problems (variations)

(iii) Being proactive in eleminating variation & continually improving the process.

(iv) Involving people in six sigma cross-functional teams.

(v) Being Flexible & thorough.



Six Sigma Methodology

- The two main six sigma methodologies are DMAIC and DMADV.
- DMAIC is a data driven method used to improve existing products or services for better customer satisfaction.

It is the acronym for the five phases:

D - Define
M - Measure
A - Analyse
I - Improve
C - Control

- DMAIC is applied in the manufacturing of a product or delivery of a service.

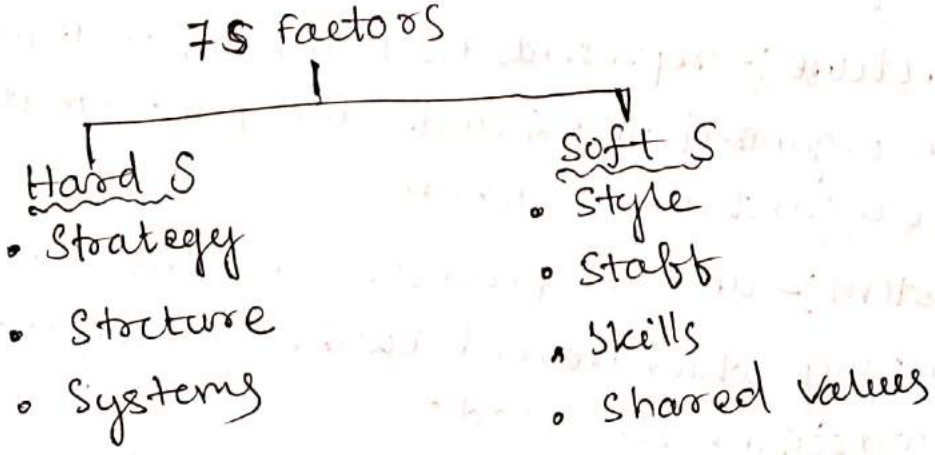
* DMADV is a part of the Design for six sigma process used to design or re-design different processes of product manufacturing or service delivery.

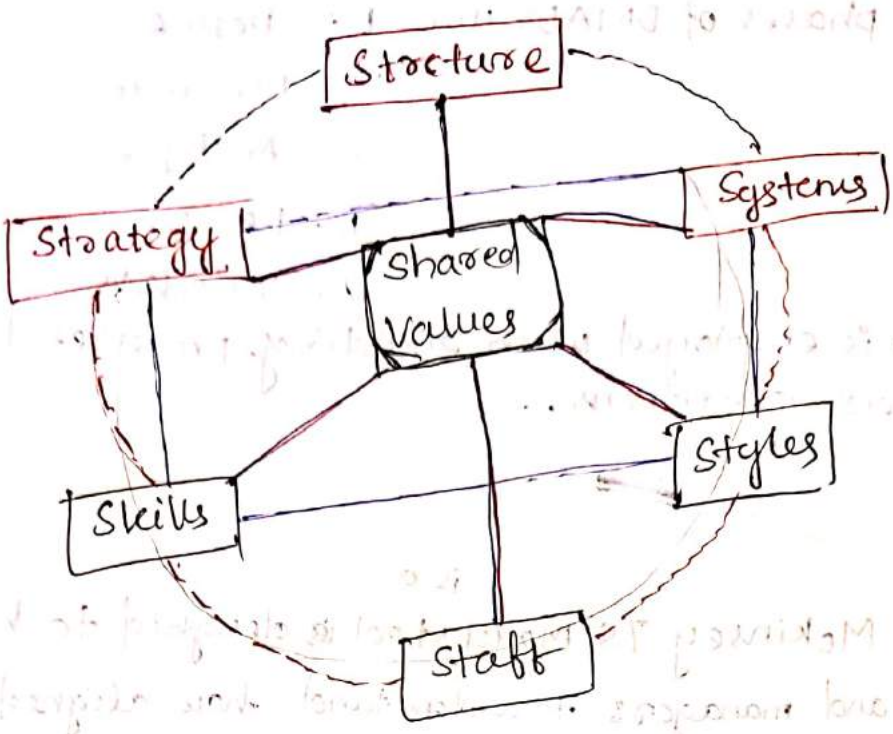
The five phases of DMADV are D - Define
M - Measure
A - Analyse
D - Design
V - Validate

- DMADV is employed when existing processes donot meet customer conditions..

* 7S

- 7S or Mckinsey 7S Model is a tool is designed to help business owners and managers to understand how aligned their organization is and how it can be improved.
- Mc kinsey 7S model was developed in 1980s by Mckinsey consultants which analyzes firm's organizational design by looking at 7S key internal elements :- Strategy, Structure, Systems, Shared values, Style, Staff and Skills
- The goal of the model is to show how 7S of the company can be aligned together to achieve effectiveness in a company & its objectives.
- The 7s are interconnected with eachother and divided into two parts. ie one is Hard S and another Softs





- Strategy, structure and systems are hard element that are much easier to identify and manage when compared to soft elements.
- On the other hand, soft areas although harder to manage, are the foundation of the organization and are more likely to create the sustained competitive advantage.

Strategy :- is a plan developed by a firm to achieve sustained competitive advantage and successfully complete in the market.

Structure :- represents the way business divisions and units are organized and includes the information of who is accountable to whom.

System :- are the processes and procedures of the company which reveal business' daily activities and how decision are made.

- Systems are the area of firm that determines how business is done and it should be the main focus

for managers during organizational change.

Skills :- are the abilities that firm's employees perform very well. they also include capabilities and competences.

Style :- represents the way, company is managed by top-level managers, how they interact, what actions do they take & their value.

Shared values :- are the core of McKinsey 7s model They are the norms and standards that guide employee behavior & company actions and thus are the foundation of every organization.

Staff :- element is concerned with what type & how many employees an organization will need & how they will be recruited, trained, motivated & rewarded.

Lean Manufacturing :-

- Lean manufacturing is a methodology that focuses on minimizing waste within manufacturing systems while simultaneously maximizing productivity.
- The benefits of lean include reduced lead times, reduced operating costs and improved product quality to name just a few.

- The five Lean Manufacturing Principles

(1) Identify Value :- The first lean principle, identifying value, is also the 1st step in the journey to become lean.
- This step requires businesses to define what customer value and how their products or services meet those values. i.e Designing of products.

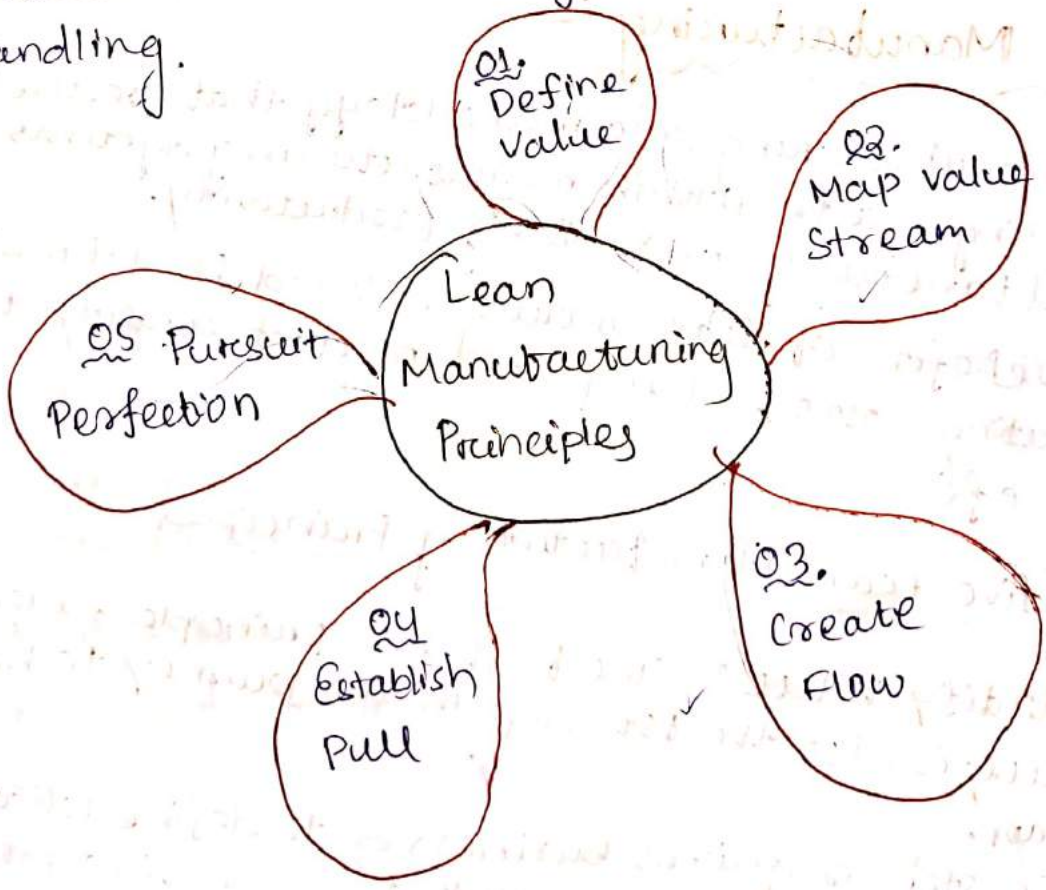
(2) Map the Value Stream :-

A value stream is the complete life cycle of a product, which includes the product's design, the customer's use of the product & the disposal of the product.

- That is mapping of entire product flow. to minimize steps that don't add value.

(3) Create Flow :-

- Efficient product flow requires ~~to~~ items to move from production to shipping without interruption and can be achieved by strategically organizing the work floor.
- A well organized work floor will result in reduced production time, inventory & size and material handling.



(04) Establish Pull :- closely related to creating flow, the fourth lean principles requires businesses to use a pull-based production system.

- Traditional production system use a push system, which starts with purchasing supplies & proceeds by manufacturing process, even though there is not an order. and it leads to result in large inventories. & significan amount of work-in-process.
- A pull system, however, pulls a customer's order from the shipping department then prompts new items to be manufactured.
- Using a pull system, busines will; increase output reduce inventories, eliminate overproduction.

05 Pursuit Perfection :-

The final lean manufacturing principle requires companies to seek perfection. It is often one of the most difficult principles to successfully apply in workplace.

- Seeking perfection requires companies to continuously improved their practices and often requires a shift in the workplace culture.

MECHANICAL Engg, BOSE, Cuttack

MST For 6th Sem

Sub :- Industrial Engg. and Quality Control.

Full Marks: 80 Time : 3hours

Answer any five Questions including Q.No - 1 & 2.

Q-1 [2×10=20]

(a) What is ideal Plant location ?

(b) Define PERT & CPM ?

(c) Define Inventory and Classify it ?

(d) Define TQM ?

(e) What do you mean by critical Activity ?

(f) Write the objectives of Inspection ?

(g) What is EOQ ?

(h) What do you mean by JIT ?

(i) Classify the types of Plant maintenance ?

(j) What is LPP ?

Q-2 [6×5=30]

(a) Write down the Advantages and Limitation of Urban location of Plant ?

(b) Maximize $12x + 24y$ · Subjected to $x + 4y \leq 20$

$3x + y \leq 15$

$x, y \geq 0$

Use graphical Method

(c) Write about ABC analysis ?

(d) What are the objectives and benefits of Inventory Control ?

(e) Write shorts notes on ISO 9000 ?

(f) Explain factors influencing the quality of Manufacture?

(g) Explain about Breakdown maintenance?

[10]

Q-3 Write the objective of Plant layout? Write the factors which affect plant layout?

[10]

Q-4 A small Engineering project consists of six activities namely A, B, C, D, E & F with duration of 5, 7, 6, 5, 4 & 4 days respectively. Draw the network diagram and calculate EST, LST, EFT, LFT and Float. Find the total project duration?

[10]

Q-5 What do you mean by control chart? Calculate UCL & LCL of P, $\bar{x}$ and R chart of the following data sample no.: 1 to 10

$\bar{x}$ → 3290, 3180, 3350, 3470, 3080, 3240, 3260, 3310, 3640, 4110

R → 560, 410, 200, 300, 90, 650, 890, 410, 1120, 520.

Where $A = 1.342$, $A_1 = 1.596$, $A_2 = 0.577$, $D_1 = 0$, $D_2 = 4.982$, $D_3 = 0$
$D_4 = 2.115$

[10]

Q-6 Explain about different stages of implementaion of TQM and its concept?

[10]

Q-7 What are the duties, functions and Responsibilities of plant maintenance department?

———×———

MECHANICAL ENGG., BOSE, Cuttack

VST For 6th Sem.

INDUSTRIAL ENGG. AND QUALITY CONTROL

(Code : MET 601)

Time: 3hours

Full Marks: 80

Answer any FIVE Questions including Q.No.-1&2

1. (a) Define plant layout. [2×10]

(b) What are the objectives of plant layout?

(c) Define Operation Research.

(d) What is TQM?

(e) Define Inventory.

(f) What is JIT Technique?

(g) Differentiate between critical and non-critical path.

(h) Define three time estimates in PERT.

(i) Write down the evolutions of ISO-9000.

(j) Classify inspection.

2. Answer any SIX questions. [5×6]

(a) Define process layout, product layout and combination layout.

(b) Explain distinct features of PERT with respect to CPM

(c) Write down the steps for graphical solution method.

(d) Define and explain ABC analysis.

(e) Describe the objectives of plant maintenance.

(f) Explain Six Sigma in quality management.

(g) Write down the factors influencing the quality of manufacture.

Scanned with CamScanner

3. Describe the features of governing plant location. [10]

4. Minimize $Z = 2x + 3y$ [10]

subject to $x + y \geq 6$

$2x + y \geq 7$

$x + 4y \geq 8$

$x, y \geq 0$

using graphical method.

5. Calculate EOQ, given that [10]

Annual usage = 100 units

Procurement cost = Rs. 25/ order

Cost per 10 pieces = Rs. 1000

Cost of carrying Inventory = 15 %.

6. Describe different types of maintenance. [10]

7. What are the different types of control chart ? [10]
Explain any two charts.

— o —

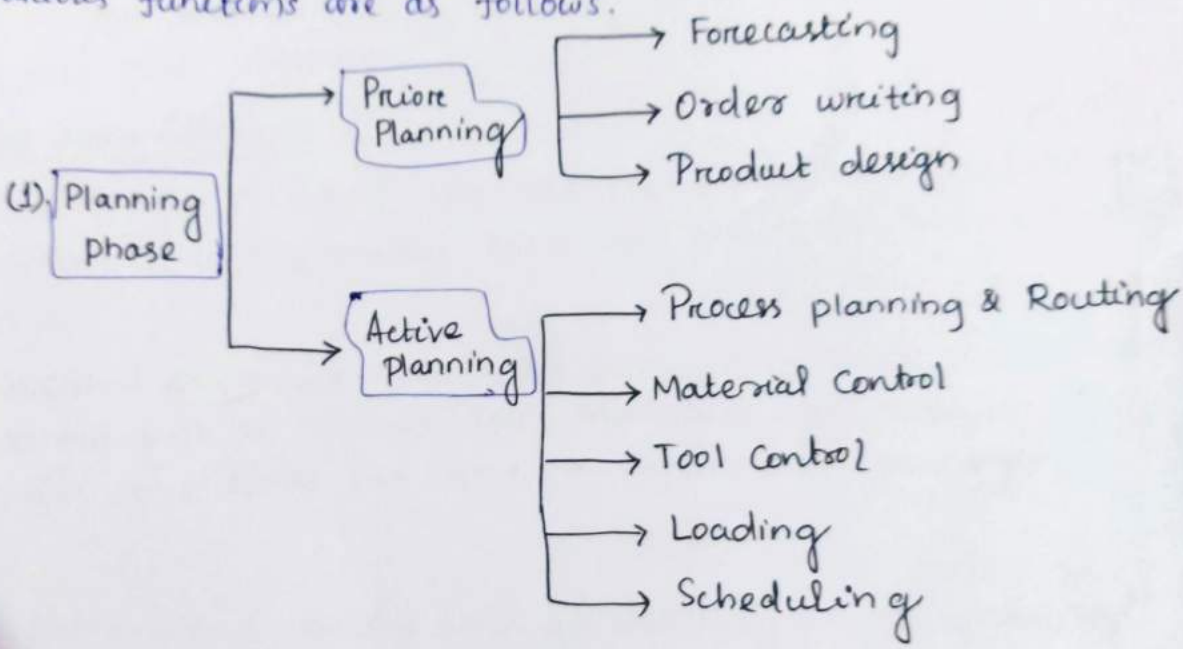
BEST OF LUCK.

Scanned with CamScanner

Production Planning & Control

A production planning and control system has many functions to perform, some before the arrival of raw materials and tools and others while the raw material undergoes processing.

- The various functions are as follows.



(2) Action Phase → Dispatching

(3) Control Phase
- Progress Reporting → Data Processing
- Corrective Action
  - Expediting
  - Replanning

② Historic estimate :-

- This technique makes use of the assumption that what happened in past will happen in future.
- It is useful if the activity is affected by pattern of seasonality.
- It is useful for determining model, size & colour distribution.
- It is successful only when pattern of events remains unchanged.
- It is not sufficient scientifically valid & thus it is not an accurate method.

ⓑ Sales Force Estimate :-

- This technique is based upon the principle - that the persons in contact with the market know best about the future market trends.
- Individual salesman make sales estimates of their territories and submit with the District sales Managers who analyses it modifies it & sends the same to Factory sales Manager.

- This technique is useful when an industry is making a limited number of product & there are afew large customers.

© Trend Line technique :-

- Trend line technique is employed where there is an appreciable amount of historic data.
- This technique is more reliable than the historic estimate
- This technique involves plotting historic data ie diagram between activity indicator e.g tons of material on Y-axis & time on X-axis.

- This technique is more accurate as it makes use of a large past data and possesses scientific validity.

Methods of Forecasting

Def^{n}:- Forecasting is a technique that uses historical data as input to make informed estimates that are predictive in determining the direction of future trends.

→ Business utilize forecasting to determine how to allocate their budgets or plan for anticipated expenses for an upcoming period of time.

→ This is typically based on the projected demand for the goods and services offered.

⇒ Forecasting plays a crucial role in the development of plans for the future.

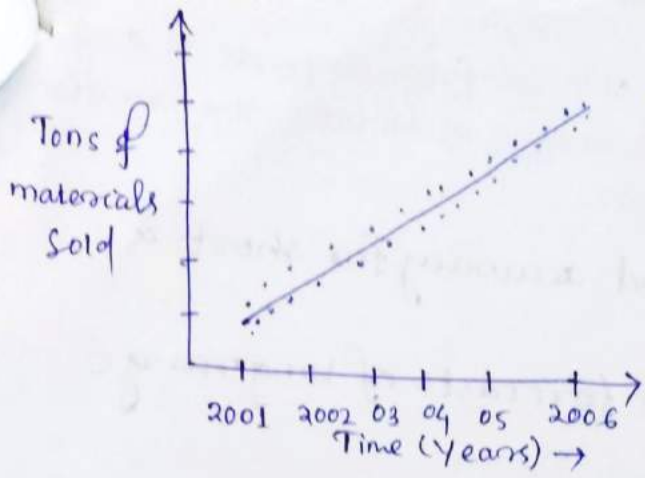
* Forecasting means estimation of type, quantity & quality of future work e.g sales etc.

Purpose of Sales Forecasting :-

- It determines the volume of production & the production rate
- It forms basis for production budget.
- It suggests the need for plant expansion.
- It emphasizes the need for product research development.

Forecasting Techniques :-

(a) Historic estimate
(b) Sales force estimate
(c) Trend line technique
(d) Market survey
(e) Delphi method
(f) Judgement Techniques.
(g) Prior knowledge.
(h) Forecasting by past average
(i) Forecasting from past period's sales
(j) Forecasting by Moving average
(k) Forecasting by weighted moving average
(l) Forecasting by Exponential Smoothing
(m) Correlation Analyses



→ However it is time-consuming, involves long mathematical calculations & assumes an infinite population of relatively small customers so that the decision of an individual customer cannot have an appreciable effect on total product demand.

(g) Market Survey (or) Research Technique :-

- This techniques finds application when a concern introduces a new product in the market and its interested to estimate its sales forecast. For a new product, naturally, no historic or past data regarding sales will be available.

- This technique may be very informal, utilizing the sales force to feel out the potential customers in order to establish the extent of the market or it may be a systematically conducted survey using special mathematical tools.

- Generally the new product is introduced in a relatively small critical trial area, market reaction is noticed and the total sales is projected from these results.

(e) Delphi Method :-

→ A panel of experts is ~~introduced~~ interrogated by a sequence of questionnaries in which the response to one questionnaire is used to produce the next questionnaire.

→ Any set of information available to some experts and not others is ~~used~~ thus passed on to others, enabling all the the experts to have access to all the information for forecasting

→ The method solicits and collates opinion from experts to arrive at a reliable consensus. This technique eliminates the bandwagon ~~expert~~ effect of majority opinion

→ Delphi method has fair to good accuracy for short & long term forecasts.

→ This method is applicable to forecasts of long range & new products sales

(i) Judgemental Technique :- & Retailer & wholesaler

- Opnions of consumers. Questionaries related to buying the product maybe sent to a selected group of consumers and to the customers who have already purchased the product. The information thus recieved can be very useful in estimating product performanee & its probable demand infuture.

(g) Prion Knowledge :-

- This is used by ancillary units which are more or less a part of the large organisation. The Large organisation ~~information~~ each ancillary unit how many component parts to make.
- The forecast estimate is needed only to establish the material & tool requirements etc.

(h) Forecasting by Past Average

This method is used where the objective is to forecast or predict the sales of an item for the next sales period.

∴ Forecasted sale for next Period = Average sales for previous period.

Example :-

Period No	Sales
1	7
2	5
3	9
4	8
5	5
6	8

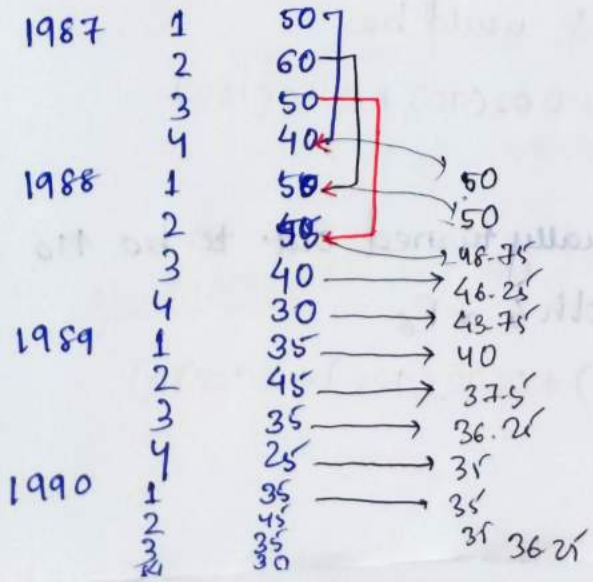
∴ Forecasted sales for period no. 7 = $\frac{7+5+9+8+5+8}{7}$ = 7

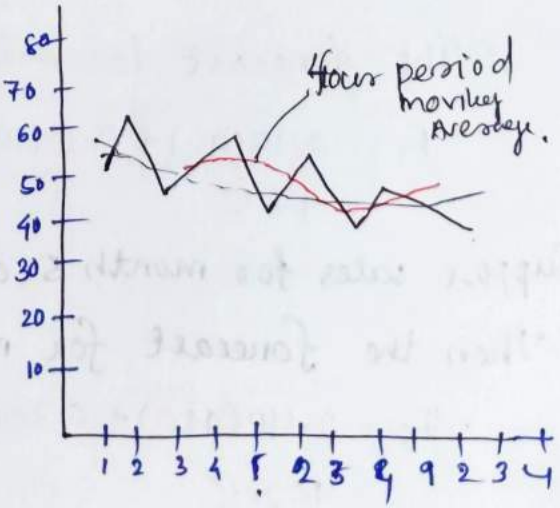
(i) Forecasting from last period's sales :-

Period no.	Annual sales	Forecast sales	Errors in Forecast
1	5		
2	4	5	+1
3	8	4	−4
4	7	8	+1
5	4	7	+3
		4	

(ii) Forecasting by Moving Average :-

- This method is the combination of Forecasting by past average & forecasting from last period's sales.
- The forecast neither influenced by very old data nor does it solely reflect the figure of the previous period.





- The graph shows that the effect of the moving average is to smooth the sale pattern and it is therefore of more value in establishing trends.

- The use of simple moving average is an adequate method of forecasting, provided sales are subject to neither seasonal variation nor marked secular trends (steadily to increase or decrease)

(K) Weighted Moving Average Method

- A weighted moving average method allows any weights to be placed on each element, providing that the sum of all weights equals one., whereas the simple moving average gave equal effects to each component of the moving average data base.

Example :- Suppose that in a four-month period the best forecast is derived by using 40% of the actual sales for the most recent month, 30% to two month ago, 20% of three month ago & 10% of four months ago.

If actual sales experience was as follows.

Month 1	Month-2	Month-3	Month 4	Month-5
100	90	105	95	?

∴ The forecast for month 5 would be

$$F_5 = 0.40(95) + 0.30(105) + 0.02(90) + 0.10(100)$$
$$= 97.5$$

Suppose sales for month 5 actually turned out to be 110

Then the forecast for month 6 = F_6

$$F_6 = 0.40(110) + 0.30(95) + 0.20(105) + 0.10(90)$$
$$= 102.5$$

→ The weighted moving average method has a definite advantage in being able to vary the effects of past data, but it also has the disadvantage of remembering the total history for the time period.

(d) Forecasting by Exponential Smoothing :-

→ The main dis-advantages of the moving average method are –

1- The lengthy calculation involved
2- The need to keep quantities of historical data.
3- The fact that the normal moving average method places equal weight on each of the historical figures used.
4- The age of the data which increase with the number of periods used.

– All of these disadvantages are overcome by the exponential smoothing technique.
– Using this technique it is necessary only to retain the previous forecast figure & to know the lastest actual sales figure. The technique works by modifying the old forecast in the light of new sales figure.

$$\text{New Forecast} = \alpha\,(\text{Lastest sales figure}) + (1-\alpha)(\text{old forecast})$$

$\because \alpha$ = smoothing constant.

– For Example :- Forecast sales for last period = 24
Actual " " " " = 22
Forecast sales for next period $= \alpha(22) + (1-\alpha)24$
$\because \alpha = 0.1$
$\Rightarrow 23.8$

→ The use of this technique permits the forecast to respond to recent actual events, but at the same time retain a certain amount of stability.

→ The amount by which the new forecast responds to the latest sales figure, or the extent to which it is damped by the previous forecast is determined by the size of the smoothing constant α.

→ The size of α should be carefully choosen in the light of the stability or variability of actual sales. α is normally from 0.1 to 0.3.

Smoothing Constant $\alpha = \frac{2}{N+1}$ for N periods.

Routing :-

- Routing means determination of the route to be followed by each part / component being tranformed from input or raw material into final product.
- Routing lays down the flow of work in the plant. It determines what work is to be done and where & how it will be done.
- Routing decides the path & sequence of operations to be performed on the job from one machine to another. by taking from raw material to the finished product.
- The purpose is to establish the optimum sequence of operations.. Routing is related to considerations of layout temporary storage of in-process inventory & material handling.

→ Routing in continuous industries does not present any problem because of the product type of layout, where the equipment is laid as per the sequence of operations required to be performed on the component.

Routing Procedures:-

Routing procedure consists of six decisions as mentioned below:-

(i) Make & Buy Decision:-

Make & buy decision depends upon the work load in the plant avialability of equipment & personnel to manufacture all components and the economy associated with making all components with in the plan itself.

(ii) Bill of Material:-

After proper analysis of the product the quality & quantity of materials required is determined & the bill of material is prepared

- A part list & a bill of materials is prepared showing name of the part, quantity, material specification amount of material s required.

Bill of Material

Ref. Drg No.

Date:-

Part no:-

Sl no.	Part no.	Name of the part	Drawing no.	Finished Component		Raw Material			No. off	W.t piece	Total	Remark
				Name	Specification	Length	Width	Thickness				

(iii) Preparation of Route Sheet :- The third step of routing procedure is the determination of operations required together with their sequence to manufacture the product.

- The routing decision establishes the operations necessary for processing the product & lists them in their sequence on route sheet or operation sheet.

Rout Sheet

Name of the part/component :- ——— Order no :- ———

Component no :- ——— Specifications - ———

Drg. no. - ——— Material - ———

Scrap Allowance - ———

Sl no	Dept no	Operation no	Operation	Specification		Manpower Required	Time per piece	Due dates	
				Machine	Tools, jigs & Fixtures			Start	End

(iv) Lot Size Determination :-

The Fourth step is to determine the lot size or the number of components to be manufactured in one lot or batch.

- In case of an orders from a particular customers, it is generally equal to a number within 10% of the order quantity.
- In other case the principle of economic batch quantity can be applied to determine the batch size.

(v) Determination of Scrap Factor :-

- The amount of waste which depends on the scraping factor is estimated.
- The actual scrap in each batch can be recorded on the control chart.
- The causes for points out of control limits are explored and corrected.

→ The variables like workers, machinery & schedules may also be adjusted to minimize scrap.

(vi) To Provide Necessary Information & Forms :-

- In order to carry out routing as planned various forms & procedures are required which furnish necessary information for the purpose.
- Various forms used e.g → Production orders, job ticket inspection ticket, move order, tool ticket & equipment ticket etc.

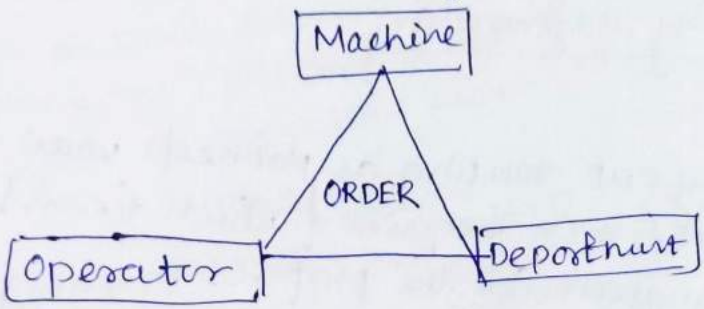
Advantages of Routing :-

(i) Effective utilization of available resources.
(ii) Reduction in production costs
(iii) Quality improvement occurs
(iv) Productivity of the system
(v) Provides a basis for loading & scheduling.

Scheduling :-

- Scheduling is the process of arranging, controlling & optimizing work & workloads in a production process or manufacturing process.
- Scheduling is used to allocate plant & machinery resources, plan human resources, plan production processes & purchase materials.

- Scheduling deals with orders and machines i.e it determine which order will be taken up on which machine & in which department by which operator.



→ The fundamental objective of scheduling is to arrange the manufacturing activities in such a way that the cost of production is minimized & the goods produced are delivered on due dates.

Factors Affecting Scheduling :-

The following factors affect production scheduling & are considered before establishing the scheduling plan.

(a) External factors

1- Customer's demand

2- Customer's delivery dates

3- Stock of goods already lying with the dealers.

(b) Internal factors

1- Stock of finished goods with the firm

2- Time interval to process finished goods from raw material.

3- Availability of equipments, materials, manpower & manufacturing facilities.

(1) Master Scheduling :-

→ The master production schedule is a production planning tool that defines how much of a production needs to be manufactured at different periods.

→ Master Production schedule (MPS) is the part of production planning that outlines which products need to be manufactured, in which quantity, & when.

Objective

- It provides a means of keeping a running total of the manufacturing requirement
- It facilitates the production manager to plan in advance for any shifting necessity from one product to another. or) for a possible overall increase or decrease in manufacturing requirements.
- It provides the required data for calculating the backlog of workload ahead of each machine.
- With the help of masters schedules the customer can be supplied with probable or certain definite data of delivery after his order has been placed on the master schedule.

Advantages :-

1. It is simple & easy to understand
2. It can be kept running (i.e. Current)
3. It involves low cost in of making & maintaing

4- It can be maintained by non-technical staff

5. A certain percentage of total weekly capacity can be allocated for such orders.

	Period 1	period-2
Starting inventory (+)	50	35
Sales forecast (-)	50	50
Quantity to Produce (+)	35	45
Ending inventory =	35	30

Disadvantages :-

- It provides only overall picture
- It doesnot give detailed information.

Dispatching

Dispatching is the routine of setting productive activities in motion through the release of orders & necessary instructions according to pre-planned times & sequence of operations embodied in route sheets & loading schedules.

→ Dispatche function executes planning function. It is concerned with getting the work started. Dispatching ensures that the plans are properly implemented.

→ It is the physical handling over of a manufacturing order to the operating facility (a worker) through the release of orders & instructions in accordance with a previously developed plan of activity (time & sequence) established by the scheduling section of the production planning & control department. Dispatcher transmits orders to the various shops.

→ Dispatch function determines by whom the job shall be done and it co-ordinates production. It is the key point of a production communication system. It creates a direct link between production & sales.

→ A dispatchers is familiar with the productivity capacity of each equipment. & the concerned person always keeps an eye over the progress of orders which move at different routes.