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SCHOOL OF MANAGEMENT STUDIES

UNIT – I – Production Management – SBAA1406

I. INTRODUCTION

Production and Production Management – Meaning – Definition – Objectives – Characteristics– Types of Production System – Productivity – Product Design – Process Planning – Production Planning and Control – Elements, Objectives, Stages, Requirements, Measurement of Effectiveness of PPC.

PRODUCTION

MEANING

Production implies the creation of goods and services to satisfy human needs. It involves conversion of inputs (resources) into outputs (products).

PRODUCTION FUNCTION

Production function is that part of an organization, which is concerned with the transformation of a range of inputs into the required outputs (products) having the requisite quality level.

Fig 1.1 : Production Function

DEFINITION

Production is defined as *"the step-by-step conversion of one form of material into another form through chemical or mechanical process to create or enhance the utility of the product to the user."* Thus production is a value addition process. At each stage of processing, there will be value addition.

Edwood Buffa defines production as *a process by which goods and services are created*.

PRODUCTION MANAGEMENT

Production/operations management is the process, which combines and transforms various resources used in the production/operations subsystem of the organization into value added product/services in a controlled manner as per the policies of the organization. Therefore, it is

that part of an organization, which is concerned with the transformation of a range of inputs into the required (products/services) having the requisite quality level. The set of interrelated management activities, which are involved in manufacturing certain Products, is called production management.

FUNCTIONS AND RESPONSIBILITIES OF A PRODUCTION MANAGER

- Product Selection and Design
- Process Selection and Planning
- Facilities Location
- Capacity Planning
- Production Planning
- Production Control
- Quality Control
- Method Analysis
- Inventory Control
- Plant Layout and material handling
- Work Measurement
- Maintenance and Replacement
- Cost reduction and Cost control

OBJECTIVES OF PRODUCTION MANAGEMENT

- Maximum customer satisfaction through quality, reliability, cost and delivery time.
- Minimum scrap / rework resulting in better product quality.
- Minimum possible inventory levels.
- Maximum utilisation of all kinds of resources needed.
- Minimum cash outflows.
- Maximum employee satisfaction.
- Maximum possible production.
- Higher operating efficiency.
- Minimum production cycle time.
- Maximum possible productivity.

CHARACTERISTICS OF PRODUCTION MANAGEMENT

- Achieving organisational goals and objectives

- There should be an improvement in profit
- Increases goodwill and reputation.
- It helps to boost the economy.
- It increases the motivation level of employees.

PRODUCTION SYSTEM

The production system of an organization is that part, which produces products of an organization. It is that activity whereby resources, flowing within a defined system, are combined and transformed in a controlled manner to add value in accordance with the policies communicated by management. A simplified production system is shown below.

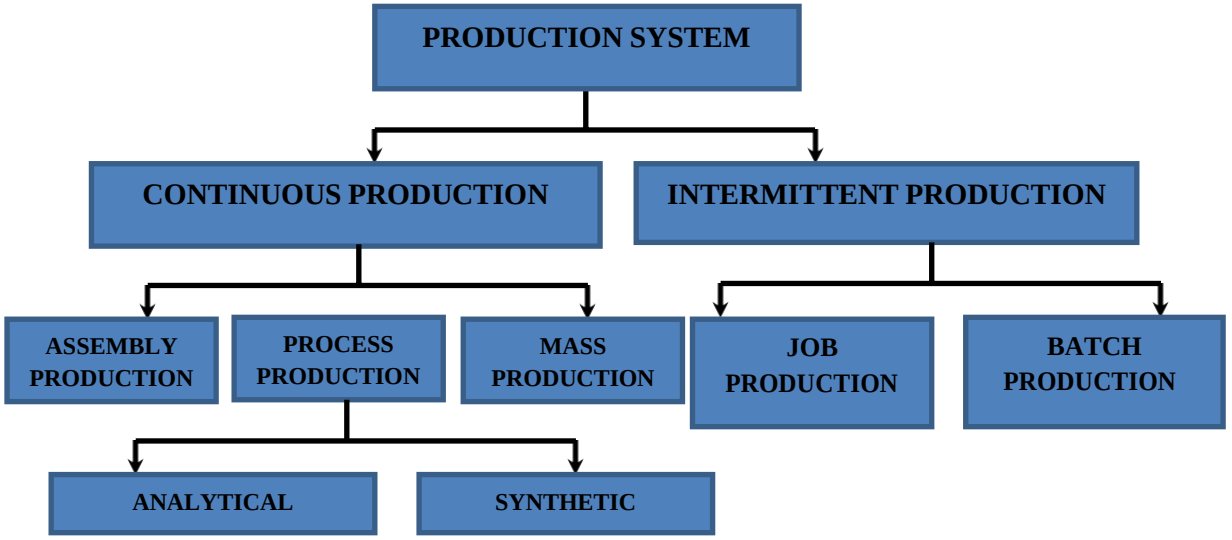

Fig 1.2 : Types of Production System

The production system has the following **characteristics**:

i. Production is an organized activity, so every production system has an objective.
ii. The system transforms the various inputs to useful outputs.
iii. It does not operate in isolation from the other organization system.
iv. There exists feedback about the activities, which is essential to control and improve system performance.

- **CONTINUOUS PRODUCTION**

Production facilities are arranged as per the sequence of production operations from the first operations to the finished product. The items are made to flow through the sequence of operations through material handling devices such as conveyors, transfer devices, etc.

a. Dedicated plant and equipment with zero flexibility.

b. Material handling is fully automated.
c. Process follows a predetermined sequence of operations.
d. Component materials cannot be readily identified with final product.
e. Planning and scheduling is a routine action.

Advantages of continuous production :

1. Standardisation of product and process sequence.

2. Higher rate of production with reduced cycle time.

3. Higher capacity utilisation due to line balancing.

4. Manpower is not required for material handling as it is completely automatic.

5. Person with limited skills can be used on the production line.

6. Unit cost is lower due to high volume of production.

Limitations of continuous production

1. Flexibility to accommodate and process number of products does not exist.

2. Very high investment for setting flow lines.

3. Product differentiation is limited.

- **MASS PRODUCTION**

Manufacture of discrete parts or assemblies using a continuous process are called mass production. This production system is justified by very large volume of production. The machines are arranged in a line or product layout. Product and process standardisation exists and all outputs follow the same path.

Characteristics of mass production

a. Standardization of product and process sequence.
b. Dedicated special purpose machines having higher production capacities and output rates.
c. Large volume of products.
d. Shorter cycle time of production.
e. Lower in process inventory.
f. Perfectly balanced production lines.

g. Flow of materials, components and parts is continuous and without any back tracking.
h. Production planning and control is easy.
i. Material handling can be completely automatic.

Advantages of mass production

a. Higher rate of production with reduced cycle time.
b. Higher capacity utilization due to line balancing.
c. Less skilled operators are required.
d. Low process inventory.
e. Manufacturing cost per unit is low.

Limitations of mass production

a. Breakdown of one machine will stop an entire production line.
b. Line layout needs major change with the change

- **PROCESS PRODUCTION**

Process manufacturing is the production of goods that are typically produced in bulk quantities, as opposed to discrete and countable units. Process manufacturing industries include chemicals, food and beverage, gasoline, paint and pharmaceutical.

- **Analytical Process**
  In Analytical Process of production, a raw material is broken into different products e.g. crude oil is analysed into gas, naptha, petrol etc. Similarly, coal is processed to obtain coal gas, coal tar etc.

- Synthetic Process
  Synthetic Process of production involves the mixing of two or more materials to manufacture a product for instance, lauric acid, myristic acid, stearic acid are synthesised to manufacture soap.

- **ASSEMBLY PRODUCTION**

Assembly line a type of flow production which is developed in the automobile industry in USA. A manufacturing unit prefers to develop and employ assembly line because it helps to improve the efficiency of production. In an assembly line, each machine must directly receive material from the previous machine and pass it directly to the next machine. Machine and

equipment should be arranged in such a manner that every operator has a free and safe access to each machine. Space should be provided for free movement of fork lifts, trucks etc. which deliver materials and collect finished products.

- **INTERMITTENT PRODUCTION SYSTEM**

Intermittent Production System According to Buffa, ―Intermittent productions are those where the facilities must be flexible enough to handle a variety of products and sizes or where the basic nature of the activity imposes change of important characteristics of the input (e.g. change. in the product design). In instances such as these, no single sequence pattern of operations is appropriate, so the relative location of the operation must be a compromise that is best for all inputs considered together‖. In the industries following the intermittent production system, some components may be made for inventory but they are combined differently for different customers. The finished product is heterogeneous but within a range of standardized options assembled by the producers. Since production is partly for stock and partly for consumer demand, there are problems to be met in scheduling, forecasting, control and coordination.

Characteristics of Intermittent Production:

a. The volume of production is generally small.
b. A wide variety of products are produced.
c. General purpose, machines and equipment's are used so as to be adaptable to a wide variety of operations.
d. No single sequence of operations is used and periodical adjustments are made to suit different jobs or batches.
e. Process layout is most suited

- **BATCH PRODUCTION**

Batch production is defined by American Production and Inventory Control Society (APICS) as a form of manufacturing in which the job passes through the functional departments in lots or batches and each lot may have a different routing. It is characterised by the manufacture of limited number of products produced at regular intervals and stocked awaiting sales.

Characteristics of Batch production

a. When there is shorter production runs.
b. When plant and machinery are flexible.

c. When plant and machinery set up is used for the production of item in a batch and change of set up is required for processing the next batch.
d. When manufacturing lead time and cost are lower as compared to job order production

Advantages of Batch production

a. Better utilisation of plant and machinery.
b. Promotes functional specialisation.
c. Cost per unit is lower as compared to job order production.
d. Lower investment in plant and machinery.
e. Flexibility to accommodate and process number of products.
f. Job satisfaction exists for operators.

Limitations of Batch production

a. Material handling is complex because of irregular and longer flows.
b. Production planning and control is complex.
c. Work in process inventory is higher compared to continuous production.
d. Higher set up costs due to frequent changes in set up.

- **JOB SHOP PRODUCTION**

Job shop production are characterised by manufacturing of one or few quantity of products designed and produced as per the specification of customers within prefixed time and cost. The distinguishing feature of this is low volume and high variety of products.

A job shop comprises of general purpose machines arranged into different departments. Each job demands unique technological requirements, demands processing on machines in acertain sequence.

Characteristics of Job Production

a. High variety of products and low volume.
b. Use of general purpose machines and facilities.
c. Highly skilled operators who can take up each job as a challenge because of uniqueness.
d. Large inventory of materials, tools, parts.

e. Detailed planning is essential for sequencing the requirements of each product, capacities for each work centre and order priorities.

Advantages of Job Production

a. Because of general purpose machines and facilities variety of products can be produced.
b. Operators will become more skilled and competent, as each job gives them learning opportunities.
c. Full potential of operators can be utilised.
d. Opportunity exists for creative methods and innovative ideas.

Limitations of job shop production

a. Higher cost due to frequent set up changes.
b. Higher level of inventory at all levels and hence higher inventory cost.
c. Production planning is complicated.
d. Larger space requirements.

PRODUCT DESIGN

Design of a product means determining the shape, standard, and pattern of the product. It includes specification, experimental, development work, calculation of estimates etc.,

STAGES IN PRODUCT DESIGN

- ✔ Conception
- ✔ Acceptance
- ✔ Execution
- ✔ Evaluation and Review of Design
- ✔ Translation
- ✔ Preproduction

Every product design passes through the following six stages

Conception : It is the first stage and the most importance stage in any product design. A draft specification is prepared at this stage by the marketing department consultation with the design department

Acceptance

Draft specification prepared earlier is scrutinised for its viability by subjecting it to all possible calculations model making, preliminary drawing, laboratory scale processes, etc, if it is not accepted, it may have to be modified or rejected and such decisions are taken jointly by design and marketing department.

Execution

In this stage involves the conversion of design specifications into drawings to build the prototype model should be a true replica of the proposed new product satisfying all the requirements of the customer.

Evaluation

The design is evaluated by a cross functional team having representatives form finance, marketing manufacturing and service department to achieve optimal design (the overall best combination of product qualities at the lowest per unit production cost)

The design is reviewed to ensure that all requirements of the product such as function, aesthetics (appearance), materials and process alternatives, and their cost, economic assembly , repair and maintenance , lead time required for installing the new process and training the labour etc, are met by the product design.

Translation

In this stage based on the experiences in the previous stages, the detailed engineering drawings for parts, subassemblies, final assemblies, parts lists etc., are prepared. These documents are known as provisional design documents which take into account the productivity aspects of the design. Also detailed estimates of costs are prepared at this stage

Preproduction

A pilot production run is carried out using the provisional design documents and the producibility aspect in this stage. Based on the experience gained in pre-production, the provisional design is modified in to final design approved for bulk production later

CHARACTERISTICS OF A GOOD PRODUCT DESIGN

1. Function

A product can be sold if it meets the needs of the consumer and as such the product must be designed to meet such needs

2. Reliability

It is the probability that there will not be any major failure of the product during its use

3. Maintainability

The lubrication points and other areas for servicing of the product to be designed ought to be easily accessible even though the physical form may have to be altered a bit.

4. Producibility

A product should be designed in such a manner that it can be produced easily at a reasonable cost. Least number of operations are required to produce a product quickly and cheaply. This may be possible with change in technology.

5. Simplification

Simplification and producibility go hand in hand the simpler the design of the product, the simpler the design of the product, the easier it is to produce, the lesser it costs and more reliable it is

6. Product standardization and variety reduction

It refers to the design activity that reduces variety among a group of products or parts.

7. Specification

A detailed description of a material part or product, including physical measures such as dimensions, volume, weight, surface finish etc

8. Safety

The product must be safe to the user and should not cause any accident while using or should not cause any health hazard to the user. Safety in storage, handling and usage must be ensured by the designer and a proper package has to be provided to avoid damage during transportation and storage of the product.

9. Appearance

This includes the style, colour, look, feel etc., which appeals to the human sense and adds value to the product.

10. Availability

This refers to the continuity of service to the customer. A product is available for use when it is in an operational state. Availability is a combination of reliability and maintainability.

TYPES OF PRODUCT DESIGN

1. Functional design

Functional design involves developing an idea in to a rough model of the proposed products

2. Aesthetic design

Before production on a commercial scale is undertaken another type of design must be integrated with the functional design and its aesthetic design for market acceptability.
Production design or product design

The functional design is translated into production design to make it easy for manufacturing.

3.Packing design

Packing design should also be appealing to the consumers depending upon the size and nature of the product. Different packing materials can be used to suit the consumer‘s taste and to maintain the chemical properties of the product.

PROCESS PLANNING

Process planning is concerned with planning the conversion processes needed to convert the raw material into finished products. Process planning is also known as process designing.

PROCEDURE OF PROCESS PLANNING OR DESIGNING A PROCESS

- **Product Design**

  Designing a process begins with the consideration or a careful review of the product design and specifications to ensure that economical manufacturing is feasible.

- **Material List**

All the materials and parts that will be used are listed. The standard quantity of each item that will be required for manufacturing one unit of final product should be determined.

- **Sequence of Operations**

  The labour operations to be performed on each component and their sequences are decided. The sequence should be such that it will permit the desired rate and quality of output at the optimum manufacturing cost.

- **Tool Design**

  The machines, equipment's and tools most appropriate for the product and volume of output are the designed. Machine setting e.g.: speed, temperature, pressure are also decided at this stage.

- **Layout**

  The layout of production, installation of manufacturing facilities and auxiliary services is decided.

- **Control System**

  Necessary control of materials, machines and manpower is established to ensure effective utilization of the manufacturing facilities and most economical production of the product.

FACTORS INFLUENCING PROCESS DESIGN

- **Volume of output**
  The quantity and rate of production affect the method of production.
- **Variety of product**
  Variety requires skilled technicians, general purpose machines, and complex production planning and control,
- **Quality of the product**
  Product quality determines the quality of component parts and materials which in turn determines the methods and equipment's.
- **Type of Equipment**
  Generally, the process engineer should attempt to design manufacturing processes that

are adaptable to and will balance the productive load of available or existing equipment that may be used in the manufacture of the product.

- **Environmental Effect**

  Process selection responds to environmental changes especially changes in technology.
- **Forms of transformational process**

  Process selection also refers to the selection of the sub-processes and so on.
- **Produce to stock vs. Produce to order**

  The important aspect is whether making production either for storage and selling or receiving an order first from the customers and then stating the production process.
- **Output characteristics vs. Process Selection**

  The selection of process form – project type, intermittent type, continuous type or continuous type depends upon the characteristics of the output.

PRODUCTION PLANNING AND CONTROL

Production Planning and Control (PPC) is a process that comprises the Performance of some critical; function on either side, viz., planning as well as Control.

Production planning without production control is like a bank without a bank manager, planning initiates action while control is an adjusting process, providing corrective measures for planned development.

Production control regulates and stimulates the orderly how of materials in the manufacturing process from the beginning to the end.

OBJECTIVES OF PRODUCTION PLANNING AND CONTROL

- Quality of output
- Plant utilization
- Process Efficiency
- Delivery of Goods
- Maintenance of Inventory
- Flexibility
- Effectiveness of work
- Absenteeism
- Team spirit
- Ideas for new methods

- Reduced Supervision
- Reduced waiting time

FUNCTIONS / ELEMENTS OF PRODUCTION PLANNING AND CONTROL

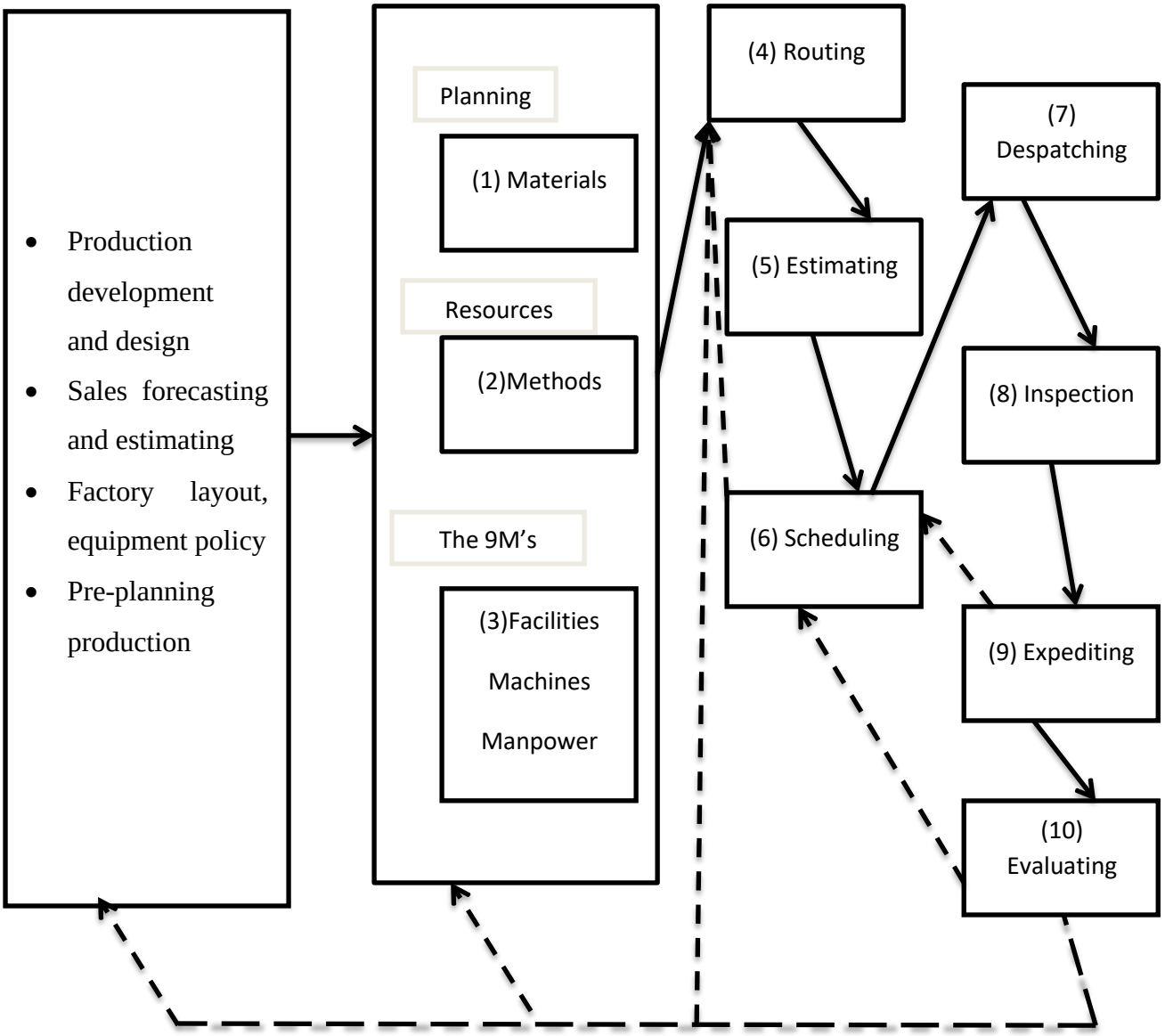

Fig 1.3 PPC

The main functions of PPC are explained below

1. **Materials**

   Raw materials, finished parts are bought-out components should be ,and available in required quantities and at required time to ensure the correct beginning and end of each operation resulting in uninterrupted production.

2. **Methods**

   This function is concerned with the analysis of alternatives and selection of the best method with the due consideration to constraints imposed.

3. **Machines and equipment**

   This function is concerned with the analysis of alternatives and selection of the best method with the due consideration to constraints imposed.

4. **Manpower**

   To maintain the availability of appropriate manpower on appropriate machines at right time.

5. **Routing**

   It is concerned with the selection of path route which the raw material should follow to get transferred into finished product.

6. **Estimating**

   Once the overall method and sequence of operations are fixed and the process sheet for each operation is available, then the operations times are estimated.

7. **Scheduling**

   Scheduling is concerned with preparation of machine loads and fixation of starting and completion date for each of the operations.

8. **Despatching**

   This is the execution phase of planning. It is the process of setting production activities in motion through release of orders and instructions.

9. **Inspection**

It is a major control tool . Though the aspects of quality control are elements of a seperate function, it is important for PPC both for the execution of the current plans and the scope for future planning.

10. **Expediting**

This is the control tool that keeps a close observation on the progress of the work which is called follow up or progress.

11. **Evaluation**

This stage is crucial to the improvement of productive efficiency. It helps to identify the weak spots and the corrective actions with respect to pre-planning and planning will be effected by feedback.

STAGES OF PRODUCTION PLANNING AND CONTROL

1. Pre-planning
2. Planning
3. Control

Pre-planning

This covers an analysis of data and outline of basic planning policy based on sales reports, market research, and product development and design. On the broad aspects of planing, this stage is concerned with problems of equipment policy, new process and materials, layout and work flow.

Planning

When the task has been specified, a thorough analysis of the 9M's is first undertaken to select the appropriate materials, methods and facilities by means of which work can be accomplished. The analysis is followed by routing, estimating and scheduling.

Control

This stage is affected by means of despatching, inspection and expediting. Control of inventories, control of scrap, analysis of work-in-progress and control and transportation are essential links at this stage. Finally evaluation takes place to complete the production planning and control cycle.

INFORMATION REQUIREMENTS OF PRODUCTION PLANNING AND CONTROL

Information	Sources of Information	Department
1. Production Programme ● Quantity to be produced ● Delivery date ● Variety and different models	The sales order or the order accepted by the marketing department	Marketing Department
2. Quality standards - specifications and tolerances	Engineering or design who translate the customer needs into specifications	Engineering, Purchase and stores
3. Production Materials ● Types of materials ● Quality and quantity ● Procurement lead time ● Stock position	Drawing and Bill of materials, Material stock cards	PPC
4. Tools	Standard and special tools	PPC department
5. Operational details • Sequence of operations, Process capacity if machines and equipments	Process sheets Load charts Process capability studies	Industrial Engineering
6. Standard time for operation and set-up time	Work measurement data	PPC
7. Starting and finishing date	Machine load and schedule charts	Production
8. Progress of work	Production reports	Production

MEASUREMENT OF EFFECTIVENESS OF PPC

- **Delivery**

  This can be easily measured by a statement of deliveries overdue with products for which they are overdue. A chart can also be made to show over a period, say every half year or annually the deliveries effected on time and those delayed, with delay-period analysis.

- **Inventories**

  The inventory turnover, the value of inventories, obsolete items, non-moving or surplus items etc., are all indicators of level of efficiency in inventory management.

- **Production management**

  Comparison of planned and actual production will be an indicator of performance. Overtime hours worked, machine - utilisation ratio etc., are other indicators for measurement of effectiveness

	PART – A	CO	Blooms Level
1.	Define Production	CO1	1
2.	State the elements of production function.	CO1	1
3.	Recall the responsibilities of a production manager.	CO1	1
4.	State the objectives of production management	CO1	1
5.	What are the characteristics of production management?	CO1	1
6.	Define Product design.	CO1	1
7.	Mention the factors influencing process design?	CO1	1
8.	What do you mean by process planning?	CO1	1
9.	Classify the types of product design?	CO1	1
10.	List of the objectives of production planning and control.	CO1	1

	PART – B	CO	Blooms Level
1.	Elaborate in detail the various types of production system.	CO1	4
2.	Discuss in detail the various stages of product design.	CO1	3
3.	Describe the characteristics of a good product design.	CO1	3
4.	Elucidate the procedure of process planning.	CO1	4
5.	Classify and explain the various elements of Production planning and control with a suitable diagram.	CO1	4
6.	Explain the information requirements of Production planning and control	CO1	3
7.	Discuss the various stages of Production planning and control in details	CO1	3
8.	Elaborate in detail about the measurement of effectiveness of PPC	CO1	4

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SCHOOL OF MANAGEMENT STUDIES

UNIT – II – Production Management – SBAA1406

II. FACILITIES LOCATION AND LAYOUT

Introduction to plant location – location need analysis – factors affecting plant location decision - Comparison of site location area – Introduction to plant layout – essentials of good plant layout – types of layout – process, product, fixed position and cell layout.

PLANT LOCATION

Plant location is the process of determining a geographical site for a firm's operations achieving maximum operating economy and effectiveness. The degree of significance for the selection of location for any enterprise mainly depends on its size and nature.

Need for location decisions

- When business is newly started
- When a business firm wants to expand its markets by adding new locations to the existing systems
- When an organisation experiences growth in demand of its products or services and the existing facility or plant not able to expand in the existing location to meet the demand.
- Shift in markets may cause firms to relocate

Importance of plant location

- Location of the plant partially determines the operating and capacity costs. It determines the nature of investment cost to be incurred and also the level of many operating costs
- Each prospective location implies a new allocation of capacity to respective market area
- Location fixes some of the physical factors of the overall plant design etc., heating and ventilation requirements, storage capacity for raw materials taking

into consideration their local availability, transportation needs for raw materials and finished goods, power needs, cost of labour, taxes, land construction etc.,

- Location helps to deliver the product at a cheaper price and thus helps a combat competition.

Objectives of plant location

- Reduced capital investment and operating cost
- Ensuring effective plant layout
- Coordination with government policies
- Employee welfare and public needs
- Security

Factors influencing Plant location

- **Factors related to buying**
  - **Nearness to raw materials**

    The cost obtaining raw materials is an influencing factor on location. The importance of nearness to raw materials varies greatly with the nature of the business.
  - **Accessibility to raw materials**

    The presence in abundance of any material is not sufficient in itself finalising the location. The location must also be easily available

- **Factors related to manufacturing**
  - **Availability of labour**

    Labour supply refers to the number of skilled and unskilled persons who are available for the kind of work to be done.
  - **Nearness to source of power**

    The sources of energy for running the wheels of industry have a decisive influence in a plant location and the development of industrial centres.
  - **Availability of services**

Services include gas, electricity, water, drainage, disposal of wastes, communication etc. These services should be available with considerable quantity.

- **Readily accessibility to repair shop**

  The factor is important mainly in case of small scale industries with plenty of orders on hand and a breakdown of its machinery will incur loss in business and being down its image.

- **Availability of amenities**

  A location which provided good external amenities – housing, shops, community services, communication systems – is often more attractive than one which is more remote. One important amenity in connection to the transport such as buses, trains etc.

- **Transport and communication**

  The next important factor is transport cost. It is possible to obtain raw materials and market finished goods only with the help of an effective transport network.

- **Safety Requirements**

  Some production units may present, or may be believed to present potential dangers to the surrounding neighbourhood for example nuclear power stations, chemical and explosives factories are often considered dangerous.

- **Adequate fire fighting facilities**

  Fire may originate from within or outside the plant. Internal fire can be controlled with fire fighting appliances but its difficult to control agencies causing fire from outside.

- **Availability of Educated Personnel and Research facilities**

  New industries as well as the development and expansion of those already established hinge on research and investigation to develop products and improve methods.

- **Ability to build and expand plant capacity**

  A plant has to be built in such a way that the manufacturing processes are carried on with minimum expenditure of time and material. Political Stability

- **Political stability**

  A government influence the development of industry by providing political stability and also subsidies.

- **Suitable soil, climate and topography**

  Soil and climate have direct bearing upon the type of activity that can be undertaken in any area in its early development
- **Association with other industries**

  Some manufacturers select locations which are near complementary or subsidiary industries.
- **The momentum of an early start**

  As a rule, people are likely to have faith in an industry that is being stated in a locality where similar ventures have been successful already.
- **Regional regulations**

  It is important to check at an early stage that the proposed location does not infringe any local regulations

- **Factors related to selling**
  - Nearness and accessibility to market
  - The advantages of being near to a market are numerous. A manufacturer can ensure quick and uninterrupted supply of his products at all the times.
  - **Characteristics of people**

    All manufacturers exist to supply markets with goods which people buy.
  - **Special grants, regional taxes and import / export barriers**

    Certain government and local authorities often offer special grants, low interest loans for setting up industries in particular locations.

Comparison of site location area

PROBLEMS

1. The potential locations Chennai, Coimbatore and Madurai have the cost structure shown for producing telecommunication sets, expected to sell for Rs. 90. Find the most economical location for an expected volume of 1850 units/year.

Site	Fixed Cost / year	Variable Cost / unit
Chennai	20,000	50
Coimbatore	40,000	30

Madurai	80,000	10

Solution :

Total cost = Fixed cost + Variable cost

Total cost at Chennai = 20000 + (50*1850) = 112500

Total cost at Coimbatore = 40000 + (30*1850) = 95500

Total cost at Madurai = 80000 + (10*1850) = 98500

From the above total cost, it is concluded that the most economical location is **Coimbatore.**

2. From the following data, select the most advantageous location for setting a plant for manufacturing products.

Description	Chennai (Rs.)	Bangalore (Rs.)	Mangalore (Rs.)
i) Total initial capital expenditure	4,00,000	4,00,000	1,00,000
ii) Total expected sales per year	5,00,000	6,00,000	5,00,000
iii) Distribution expenses	80,000	80,000	1,50,000
iv) Raw material expenses	1,40,000	1,60,000	1,80,000
v) Power and water supply	80,000	60,000	40,000
vi) Wages & salaries	40,000	50,000	40,000
vii) Other expenses	50,000	80,000	60,000

viii) Community Attitude	Indifferent	Excellent	Indifferent
ix) Employee's housing facilities	Poor	Excellent	Poor

Solution

$$\text{Rate of Return} = \frac{(\text{Total Sales} - \text{Total Expenses})}{\text{Total Investment}} * 100$$

Total expenses for Chennai = 3,90,000

Total expenses for Bangalore = 4,30,000

Total expenses for Mangalore = 4,70,000

Rate of Return of Chennai = (5,00,000-3,90,000)/4,00,000 *100 = 27.5%

Rate of Return of Bangalore = (6,00,000-4,30,000)/4,00,000 *100 = 42.5%

Rate of Return of Mangalore = (5,00,000-4,70,000)/1,00,000 *100 = 30%

Since **Bangalore** has the highest rate of return, Bangalore is the most advantageous location for setting a plant for manufacturing products.

PLANT LAYOUT

Meaning

Plant layout is the physical arrangement of industrial facilities. It involves the allocation of space & the arrangement of equipment in such a manner that overall operating costs are minimized.

Objectives of plant layout

1. Economies in materials facilitate the manufacturing process & handling of semi-finished & finished goods.
2. Proper & efficient utilization of available floor space.
3. To avoid congestion & bottlenecks.
4. Provision of better supervision & control of operations.
5. Careful planning to avoid frequent changes in layout which may result in undue increase in cost of production.
6. To provide adequate safety to the workers from accidents.
7. To meet the quality & capacity requirements in the most economical manner.
8. Provision of medical facilities & cafeteria at suitable & convenient places.
9. To provide efficient material handling system.
10. To suggest the improvements in production process & work methods.

Principles of plant layout

1. Principle of integration (of 5M‘s)
2. Principle of minimum distance
3. Principle of cubic space utilization (both horizontal & vertical space).
4. Principle of flow(must be forward no backtracking)
5. Principle of maximum flexibility
6. Principle of safety, security & satisfaction
7. Principle of minimum handling.

Factors affecting plant layout

1. **Nature of product-** e.g. some products need air-conditioned plants.
2. **Size of output-**
   For bulk-product/line layout
   For small-functional layout
3. **Nature of manufacturing system-**
   For intermittent-functional layout
   For continuous-product/line layout

4. **Localization of plant-** e.g. there will be different transportation arrangement if site is located near railway line.

5. **Machines or equipment-** e.g. heavy machines need stationary layout

6. Climatic conditions, need of light, temperature also affect design of layout.

Types of plant layout

- Product layout
- Process layout
- Fixed Position/ Stationary layout
- Cellular or group layout
- Service Facility Layout
- Combined Layout

1. Product layout

A product layout groups different workstations together according to the products they work on. Workstations in a product layout can quickly transfer small batches of semi-finished goods directly to the next station in a production line. Product layouts can be ideal for smaller manufacturing businesses with lower volume than their large corporate competitors.

Layout that uses standardized processing operations to achieve smooth, rapid, high-volume flow. Here machines are arranged according to the needs of product & in the same sequence as the operations are necessary for manufacture. E.g. _back office‘ of services such as banks and insurance companies.

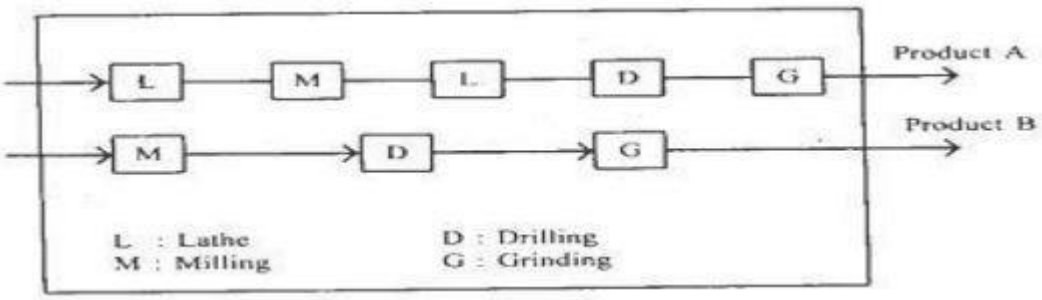

Fig 2.1 Product Layout

Advantages of Product Layout

- High rate of output

- Low unit cost
- Labor specialization
- Low material handling cost
- High utilization of labor and equipment
- Established routing and scheduling
- Short processing time

Disadvantages of Product Layout

- Creates dull, repetitive jobs
- Poorly skilled workers may not maintain equipment or quality of output
- Fairly inflexible to changes in volume
- Highly susceptible to shutdowns
- Needs preventive maintenance
- Require large capital investment

2. **Process layout**

A process layout groups workstations together according to the activities being performed, regardless of which products each workstation is working on. Workstations produce higher volumes of output at a time before sending semi-finished goods in bulk to the next area, which may be located as close as the other end of a building or as far as another facility on the other side of the globe.

Layout that can handle varied processing requirements. Here all machines performing similar types of operations are grouped together at one location in the process layout. Thus here facilities are grouped together acc. To their functions. E.g. all drilling machines are located at one place known as the drilling section.

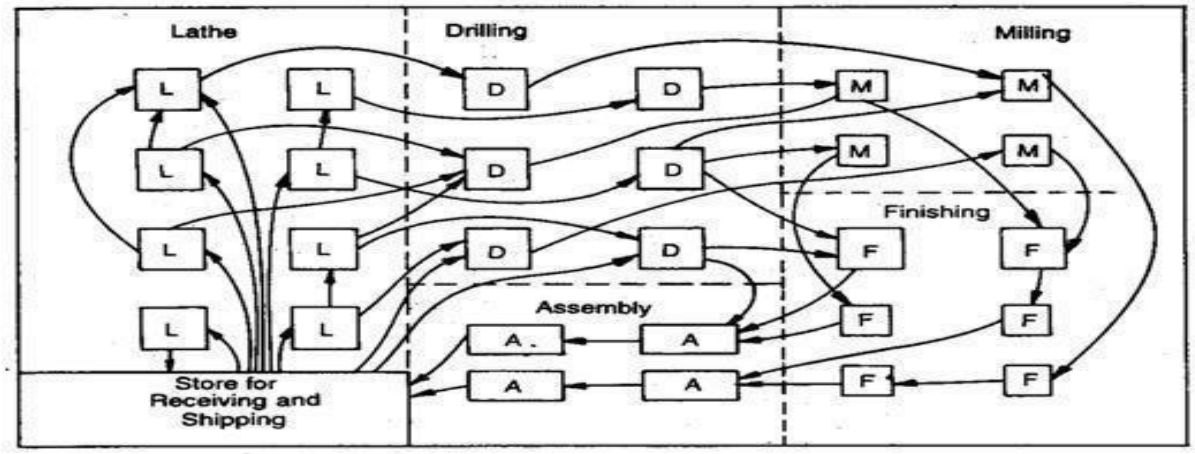

Fig : 2.2 Process Layout

Advantages of Process Layouts

- Can handle a variety of processing requirements
- Machines breakdown doesn‘t result in shutdown.
- Equipment used is less costly
- Wide flexibility in production facilities.
- Each production unit of system works independently.
- High utilization of facilities
- Variety makes the job interesting.

Disadvantages of Process Layouts

- In-process inventory costs can be high
- Challenging routing and scheduling
- Equipment utilization rates are low
- Material handling is slow and inefficient & is more.
- More space is required
- Longer processing time
- Backtracking may occur.

3. **Stationary layout:**

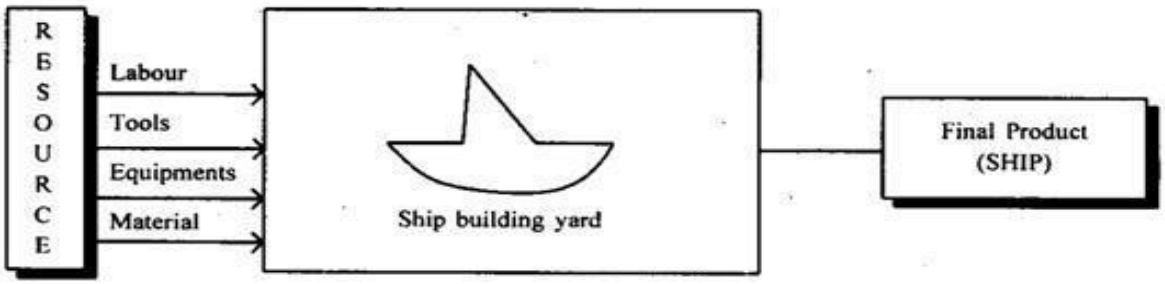

Fig 2.3 Stationary Layout

Stationary Layout in which the product or project remains stationary, and workers, materials and equipment are moved as needed. Eg. Construction of DAMS. The product, because of its size and/or weight, remains in one location and processes are brought to it.

4. **Cellular or group layout**

Cellular layout is based on the group technology (GT) principle. Therefore, it is also called as group layout. This layout is suitable for a manufacturing environment in which large variety of products are needed in small volumes (or batches). The group technology principle suggests that parts, which are similar in design or manufacturing operations, are grouped into one family, called part-family.

For each part-family a dedicated Cluster of machines (called machine cell) are identified. Generally, all the processing requirements of a particular part-family are completed in its corresponding machine ceil. In other words, the intercell transfer UT part should ideally be zero."

The cellular layout is thus a combination of process and product layout. Therefore, it possesses the features of both. Cellular manufacturing system (CMS) involves decomposition of manufacturing system into subsystems of similar parts/machines. CMS allows batch production to give economic advantages similar to those of mass production with additional advantages of flexibility, normally associated with job shop production systems

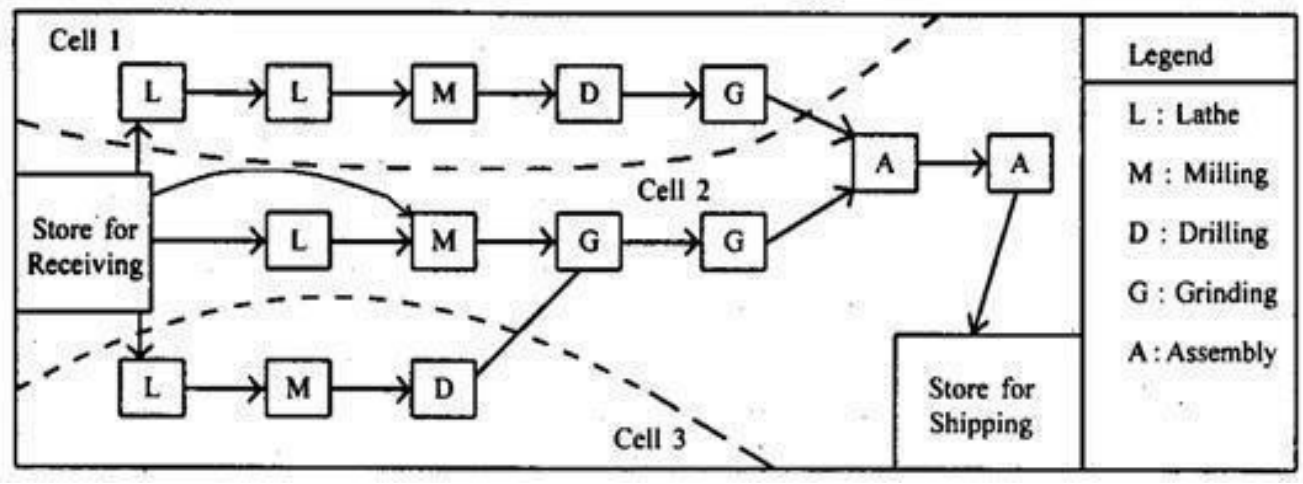

Fig 2.4 Cellular Layout

Service facility Layout

The fundamental difference between service facility and manufacturing facility layouts is that many service facilities exist to bring together customers and services. Service facility layouts should provide for easy entrance to these facilities from freeways and busy thoroughfares. large, well organized and amply lighted parking areas and well-designed walkways to and from parking areas are some of the requirements of service facility layouts.

Combined Layout

The application of the principles of product layout or fixed location layout in their strict meanings is difficult to come across. A combination of the product and process layouts, with an emphasis on either, is noticed in most industrial establishments. Plants are never laid out in either pure form. It is possible to have both types of layout in an efficiently combined form if the products manufactured are somewhat similar and not complex.

****

	PART – A	**CO**	**Blooms Level**
1.	Define plant location.	CO2	1
2.	Why do you need location decisions to be taken?	CO2	2
3.	List out the objectives of plant location.	CO2	1
4.	State the importance of plant location.	CO2	1
5.	Recall the term ‘plant layout’.	CO2	1
6.	State the objectives of plant layout.	CO2	1

7.	Mention the principles of plant layout.	CO2	1
8.	What are the factors affecting plant layout?	CO2	1
9.	Draw a suitable diagram for product layout.	CO2	4
10.	What do you mean by service facility layout?	CO2	2

<table>
<tr><th colspan="2">PART – B</th><th>CO</th><th>Blooms Level</th></tr>
<tr><td>1.</td><td>Explain in detail the factors influencing the plant location.</td><td>CO2</td><td>4</td></tr>
<tr><td>2.</td><td>The potential locations Chennai, Coimbatore and Madurai have the cost structure shown for producing telecommunication sets, expected to sell for Rs. 80. Find the most economical location for an expected volume of 1750 units/year.
<table>
<tr><th>Site</th><th>Fixed Cost/ Year</th><th>Variable cost / Unit</th></tr>
<tr><td>Chennai</td><td>15,000</td><td>40</td></tr>
<tr><td>Trichy</td><td>30,000</td><td>30</td></tr>
<tr><td>Madurai</td><td>60,000</td><td>10</td></tr>
</table></td><td>CO2</td><td>5</td></tr>
<tr><td>3.</td><td>From the following data, select the most advantageous location for setting a plant for manufacturing products.
<table>
<tr><th>Description</th><th>Chennai (Rs.)</th><th>Madurai (Rs.)</th><th>Mangalore (Rs.)</th></tr>
<tr><td>i) Total initial capital expenditure</td><td>4,00,000</td><td>4,00,000</td><td>1,00,000</td></tr>
<tr><td>ii) Total expected sales per year</td><td>5,00,000</td><td>6,00,000</td><td>5,00,000</td></tr>
<tr><td>iii) Distribution expenses</td><td>80,000</td><td>80,000</td><td>1,50,000</td></tr>
<tr><td>iv) Raw material expenses</td><td>1,40,000</td><td>1,60,000</td><td>1,80,000</td></tr>
<tr><td>v) Power and water supply</td><td>80,000</td><td>60,000</td><td>40,000</td></tr>
<tr><td>vi) Wages & salaries</td><td>40,000</td><td>50,000</td><td>40,000</td></tr>
<tr><td>vii) Other expenses</td><td>50,000</td><td>80,000</td><td>60,000</td></tr>
</table></td><td>CO2</td><td>5</td></tr>
<tr><td>4.</td><td>Classify the various types of plant layout with suitable diagram? Explain.</td><td>CO2</td><td>4</td></tr>
</table>

<table>
<tr>
<td>5.</td>
<td>The potential locations A, B and C have cost structures shown below. The selling price of the product is Rs.120. Find the most economic location for an expected volume of 2000 units per year.
<table>
<tr><th>Location</th><th>Fixed cost/ Year</th><th>Variable cost / Unit</th></tr>
<tr><td>A</td><td>30,000</td><td>75</td></tr>
<tr><td>B</td><td>60,000</td><td>45</td></tr>
<tr><td>C</td><td>1,10,000</td><td>25</td></tr>
</table>
</td>
<td>CO2</td>
<td>4</td>
</tr>
</table>

Reference

Chary S., Production and Operations Management, 5th Edition, Tata McGraw Hill, 2017.

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SCHOOL OF MANAGEMENT STUDIES

UNIT – III – Production Management – SBAA1406

III. MATERIALS HANDLING AND MAINTENANCE

Material handling – Principles of material handling – Material handling equipment – Maintenance – Types of maintenance – Procedure for maintenance

MATERIAL HANDLING

"Material handling is the art and science involving the moving, packaging, and storing of substance in any form".

OBJECTIVES OF MATERIALS HANDLING

- Lower unit material handling costs.
- Reduction in manufacturing cycle time though faster movement of materials and by reducing the distance through which the materials are moved. Reduction in manufacturing cycle time results in reduced work in progress inventory costs.
- Contribution towards a better control of the flow of materials though the manufacturing facility
- Improved working conditions and greater safety in the movement of materials.
- Contribute to better quality by avoiding damage to products by inefficient handling.
- Increased storage capacity through better utilization of storage areas.
- Higher productivity at lower manufacturing cost.

PRINCIPLES OF MATERIALS HANDLING

Materials should move through the facility in direct flow pattern, minimizing, zig zagging or backtracking.

- Related production processes should be arranged to provide for direct material flows.
- Mechanized materials handling devices should be designed and located so that human's effort is minimized.
- Heavy and bulk materials should be moved the shortest distance during processing.
- The number of times each material is handled should be minimized.

- Systems flexibility should allow for unexpected breakdowns of materials handling equipment's change in production system technology, etc.
- Mobile equipment's should carry full loads all the times.

PROBLEMS IN MATERIALS HANDLING

- Frequent stoppage of production for want of materials (raw materials or semi processed parts) due to delay in handling and moving the required materials to the point of use.
- Waste of labor skills by using skilled workers to do materials handling functions such as loading, unloading, moving and storing materials.
- Damage caused to materials which are handled due to negligence or use of improper handling boxes and handling equipment's.
- Accumulation of material of all kinds at all places waiting for movement.
- Bad handling cause damage to the materials handled, thereby necessitating rework or resulting in scrap (rejected materials due to defects caused by negligence in handling).
- Conjunction of floor space near the materials and work centers and near the gang ways or aisles. Conjunction of space at receiving stores, holding stores, production and inspection areas.
- Materials are kept waiting for a long period for want of material handling equipment to pick up and move the materials to their destinations.

MATERIALS HANDLING EQUIPMENTS

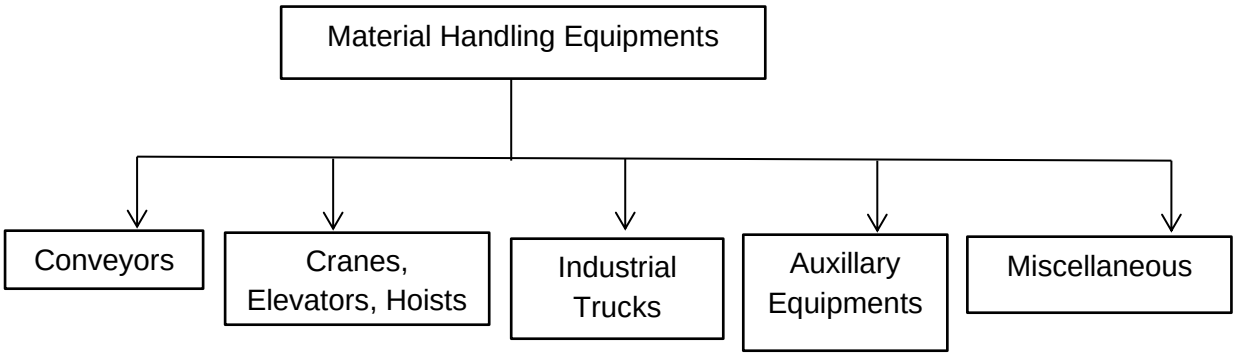

Fig 3.1 Material Handling Equipments

- **CONVEYOR**

These are gravity or powered devices. Commonly used for moving loads from point to point over fixed paths. There are various types of conveyors such as

- ❖ Belt conveyor
- ❖ Chain conveyor
- ❖ Roller conveyor
- ❖ Pneumatic conveyor

- **Belt conveyor**

Belt Conveyor is a one kind of mechanism that to transfer the material constantly. Motor driven belt, usually made of rubberized fabric or metal fabric on a rigid frame.

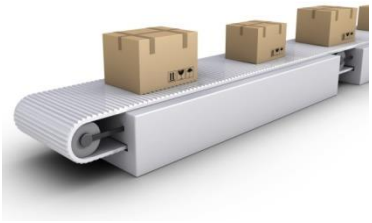

Fig 3.2 : Belt conveyor

- **Chain conveyor**

Chain conveyors are often utilized to transport coal, wood, refuse, and scrubber sludge in pulp and paper mills, waste to energy facilities and coal fired electric power plants.

Fig 3.3: Chain conveyor

- **Roller conveyor**

  A series of rollers supported in a frame over which objects are advanced manually, by gravity or by power. Boxes, large parts or unit loads roll on top of a series of rollers mounted on a rigid frame. The rollers may be powered or unpowered.

Fig 3.4 : Roller conveyor

- **Pneumatic conveyor**

  Pneumatic conveyors are continuous conveyors for bulk material in which material is conveyed in an enclosed tube system by means of compressed air or by means of a vacuum. High volume of air flows through a tube, carrying materials along with the airflow.

Fig 3.5 : Pneumatic conveyor

- **CRANES, ELEVATOR and HOISTS**

  Crane is defined as a large machine used to lift and move very heavy things. Cranes are devices mounted on overhead rails or ground level wheels or rails. They lift, swing and transport large and heavy materials. Examples are Gantry cranes, Jib crane and electrically operated overhead crane

Fig 3.6: Crane

Elevators are type of cranes that lift materials – usually between floors of buildings

Fig 3.7 : Industrial elevator

Hoists are devices which move materials vertically and horizontally in a limited area. They are used primarily when materials must be lifted prior to being moved from one point to another. Examples of hoists are air hoist, electric hoist and chain hoist.

Fig 3.7 : Electric hoist

➢ **INDUSTRIAL TRUCKS**

These devices are used for moving mixed or uniform loads intermittently over variable paths. They are electric, diesel, gasoline and liquefied petroleum, gas powered vehicles equipped beds, forks, arms or other holding devices. Examples are fork-lift trucks, pallet trucks, tractors with trailors, hand trucks and power trolleys.

- **Fork lift truck**

A forklift is a powered industrial truck used to lift and move materials over short distances.

Fig 3.8 : Forklift

- **Tractor trailer truck**

Tractor-trailer truck is the combination of a tractor unit and one, or more, semi-trailers to carry freight.

Fig 3.9 : Tractor trailer truck

- **Pedestrian LED powered industrial truck**

Pedestrians can avoid this by paying attention to the surroundings, staying a safe distance away from truck.

Fig 3.10: Pedastrian LED powered industrial truck

- **AUXILLARY EQUIPMENTS**

  These are devices or attachments used with handling equipment to make their use more effective and versatile. Examples are ramps, positioners, pallets, containers and turn tables.

- **Expendable pallet**

  A pallet utilized for a single transaction and is not expected to be returned. Expendable pallets are usually combined with an outer wooden packaging shell, however they can also be used separately with plastic wrap to secure the goods.

Fig 3.11: Expendable Pallet

- **Skid boxes**

  A skid box, also known as a bulk box, pallet box, bin box, or octabin is a pallet-size box used for storage and shipping of bulk quantities.

Fig 3.12: Skid box

➢ MISCELLANEOUS HANDLING EQUIPMENTS

- **Pipelines**

Pipe lines which are closed tubes that transport liquid by means of pumps or gravity. Piping is a system of pipes used to convey fluids (liquids and gases) from one location to another.

Fig 3.13: Pipe lines

- **Automatic transfer devices**

Automatic transfer devices act as the "brain" of your entire electrical system. Once installed, they can automatically switch between electricity coming from your utility and generator power.

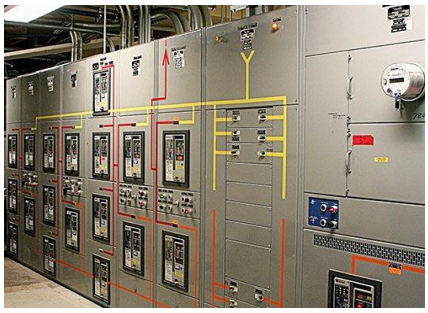

Fig 3.14: Automatic transfer devices

- **Industrial robots**

A robot is a mechanism which has movable arm like projection with gripper on the end that can perform a variety of repetitive tasks. Robots usually have a built-in

control that can be reprogrammed and hence they are very versatile. An industrial robot is a robot system used for manufacturing.

Fig 3.15: Industrial Robots

MAINTENANCE MANAGEMENT

MAINTENANCE

Maintenance is defined as "that function of production management that is concerned with the day to day problem of keeping the physical plant in good operating condition.

MAINTENANCE MANAGEMENT

Maintenance management is concerned with the direction and organization of resources in order to control the availability and performance of the industrial plants to some specified level.

OBJECTIVES OF MAINTENANCE MANAGEMENT

- Minimizing the loss of productive time because of equipment failure (i.e., minimizing idle time of equipment due to break down).
- Minimizing the repair time and repair cost.
- Minimizing the loss due to production stoppage.
- Efficient use of maintenance personnel and equipment.
- Prolonging the life of capital assets by minimizing the rate of wear and tear.
- To keep all productive assets in good working condition.
- To maximize efficiency and economy in production through optimum use of facilities.

- To minimize the total maintenance cost which includes the cost of repair,cost of preventive maintenance and inventory carrying costs due to spare parts inventory.
- To improve the quality of products and to improve productivity.

AREAS OF MAINTENANCE

- **Civil Maintenance**: Building construction and maintenance, maintaining service facilities such as water, gas, steam, compressed air, heating and ventilating, air conditioning, painting, plumbing and carpentry work.
- **Mechanical Maintenance:** Maintaining machines and equipment transport vehicles, material handling equipment, steam generators, boiler compressors and furnace. Lubricating the machines is also part of mechanical maintenance work.
- **Electrical maintenance:** Maintaining electrical equipment's such as generators, transformers, switch gears, motors, telephone systems, electrical installations, lighting, fans, meters, gages, instruments, control panels battery charging.

TYPES OF MAINTENANCE

- **Break Down or Corrective Maintenance:** As the name suggests, corrective maintenance occurs when there is a work stoppage because of machine breakdown. The breakdown maintenance seeks to achieve the following objectives
    - ✓ To get equipment back into operation as quickly as possible in order to minimize interruption to production.
    - ✓ To control the cost of repair crews, including regular time and overtime labour costs.
    - ✓ To control the cost of the operation of repair shops.
    - ✓ To control the investment in replacement spare parts that are used when machines are repaired.

    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 machinery, equipment getting too much heated up, etc.

- **Preventive Maintenance:** Preventive maintenance is undertaken before the need arise and aims to minimize the possibility of unanticipated production interruptions or major breakdowns. Preventive maintenance should contain the following features

  - ✓ Proper identification of all items to be included in the programme.
  - ✓ Adequate records covering, volume of work, cost and so on.
  - ✓ Inspection on a definite schedule
  - ✓ Use of checklists by inspectors
  - ✓ An inspection frequency schedule
  - ✓ Well qualified inspectors
  - ✓ Use of repair budgets for major items of equipment.
  - ✓ Administrative procedures that provide necessary fulfillment and follow-up on programme.
- **Predictive Maintenance:** one of the newer types of maintenance that may be anticipated to gain increasing attention is called predictive maintenance.in this sensitive instrument (e.g., vibration analyzers, amplitude meters, audio gauge, optical tooling, pressure, temperature and resistance gauge) are used to predict trouble.

- **Routine Maintenance:** This includes activities such as periodic inspection, cleaning, lubrication and repair of production equipment's after their service life. Routine maintenance may be classified as:

  - ✓ Running Maintenance in which the maintenance work is carried out while the equipment is in the operating condition (i.e., performance some operation) e.g., greasing or lubricating the bearings while the machine is running.
  - ✓ Shut down maintenance in which the maintenance work is carried out when the machine or equipment is out of service i.e., after shutting down the machine or equipment. e.g., repairing (i.e., descaling) boiler tubes of a boiler.
- **Planned Maintenance:** Break down of a machine or equipment does not occur in a planned manner but maintenance work can be planned well in advance. Planned maintenance according to predetermined schedule is also known as scheduled maintenance or productive maintenance. It allows inspection of all plants and

equipment's, machinery, buildings in order to service. It aims to reduce machine stoppage due to sudden breakdown necessitating emergency maintenance.

PROCEDURE FOR PREVENTIVE MAINTENANCE

The various steps involved are

- Job identification or preparing facility register
- Preparation of preventive maintenance schedule
- Preparation of history card
- Preparation of job specification
- Preparation of preventive maintenance program
- Preparation of preventive maintenance schedule
- Preparation of inspection report
- Preparation of maintenance report
- Feedback mechanism

i. **Job identification or preparing facility register:** A facility register defines what is to be maintained. It gives a list of plant, equipment's and machinery and other facilities which are to be brought under the purview of preventive maintenance.

ii. **Preparation of preventive maintenance schedule:** A maintenance schedule indicates the method, time and place of carrying out maintenance work. It gives information about maintenance crew available and the time phasing of maintenance loading on maintenance crew.

iii. **Preparation of history card:** Machine history card gives complete record of all repairs, replacement and engineering changes carried out on equipment or machinery during its service period. It also gives frequency of occurrence of break downs, rate of wear of different components, total machine or equipment down time due to failure and repair.

iv. **Preparation of job specification:** Job specification is a document which provides useful information about the maintenance work to be done. They are prepared for each maintenance job and serve as guide for maintenance crew.

v. **Preparation of preventive maintenance program:** It is a list which indicates allowance of specific maintenance work to a specific period.

vi. **Preparation of preventive maintenance schedule (Weekly or monthly) :** According to the importance of machines/equipment's, their maintenance schedule is prepared.

The maintenance programme includes the following:

a) Reconditioning or replacing of worn out part or tools.
b) Repairing or replacing worn out parts or tools.
c) Checking all electrical connection of the machine or equipment.
d) Checking the performance of each part of the machine or equipment.
e) Cleaning of interior parts such as gear box, radiator etc., of transport and material handling equipment's.
f) Checking of control systems.
g) Complete overhauling.

vii. **Preparation of maintenance report:** The inspection staff periodically inspects the machines and equipment's as per inspection schedule and submit a report regarding their finding to the maintenance foreman for necessary action.

viii. **Preparation of maintenance report:** It is a document which indicates the various suggestions and recommendations given by inspection report. It includes feedback form operators also regarding the condition of the equipment's or machines.

ix. **Feedback mechanism:** This is the last step in which the corrective and control actions are applied as and when required on the basis of feedback information. This corrective action forms the basis for designing and improving the maintenance program for the future.

****

	PART – A	**CO**	**Blooms Level**
1.	Define Material handling.	CO3	1
2.	Identify the objectives of material handling.	CO3	1
3.	State the principles of material handling	CO3	1
4.	List out the limitations of material handling.	CO3	1
5.	Classify the types of conveyors.	CO3	2
6.	Define the term maintenance.	CO3	1

7.	Define maintenance management.	CO3	1
8.	List out the various areas of maintenance.	CO3	1
9.	Recall the term ‘breakdown maintenance’.	CO3	1
10.	State the term ‘predictive maintenance’.	CO3	1

PART – B		**CO**	**Blooms Level**
1.	Discuss in detail about material handling.	CO3	3
2.	Classify the various material handling equipment’s and mention the purpose of the equipment’s.	CO3	3
3.	Explain in detail the procedure of preventive maintenance.	CO3	3
4.	Categorize and discuss the various types of maintenance.	CO3	5
5.	Explain in detail the various areas of maintenance.	CO3	3

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SCHOOL OF MANAGEMENT STUDIES

UNIT – IV – Production Management – SBAA1406

IV. WORK AND METHOD STUDY

Work and Method study – Importance of work study – Work study procedures – Time study – human considerations in work study – Introduction to method study Objectives of method study – Steps involved in methods study. Work measurement – Objectives of work measurement – techniques of work measurement – Computation of standard time – allowance – Comparison of various techniques.

WORK STUDY

Work study is defined as that body of knowledge concerned with the analysis of the work methods and the equipment used in performance a job, the design of an optimum work method and the standardization of proposed work method.

Work study is defined by British Standard Institution as follows "a generic term for those techniques, particularly method study and work measurement which are used in the examination of human work in all its contexts and which lead systematically to the investigation of all the factors which affect the efficiency and economy of the situation being reviewed in order to effect improvement.

IMPORTANCE OF WORK STUDY

- To improve productivity of current jobs and maximize productivity of jobs designed for the future, subject to constraints.
- To reduce waste through standardization of work elements of a job.
- To increase industrial productivity through job standardization.
- To analyze the present method of doing a job systematically, in order to develop a new and better method (referred to as method study or method analysis).
- To measure the work content of a by measuring the time required to do the job for a qualified worker and hence to establish the standard time for the job elements as well as the whole job (referred to as work measurement).
- To improve labour (or operational) efficiency.
- To enable most optimal utilization of plant and equipment.
- To enable optical utilization of plant and equipment.

- To ensure most effective utilization of human effort.
- To determine efficient work methods.
- To evaluate human effort.
- To establish standard of performance for employees.
- To standardize the method, material and equipment used in the production process and also to establish an optimum sequence of operations and the plant layout that minimize the materials handling time and cost.
- To increase productivity by ensuring the best possible use of all resource (human, machine and material) to achieve best quality product service at minimum possible cost

SCOPE OF WORK STUDY

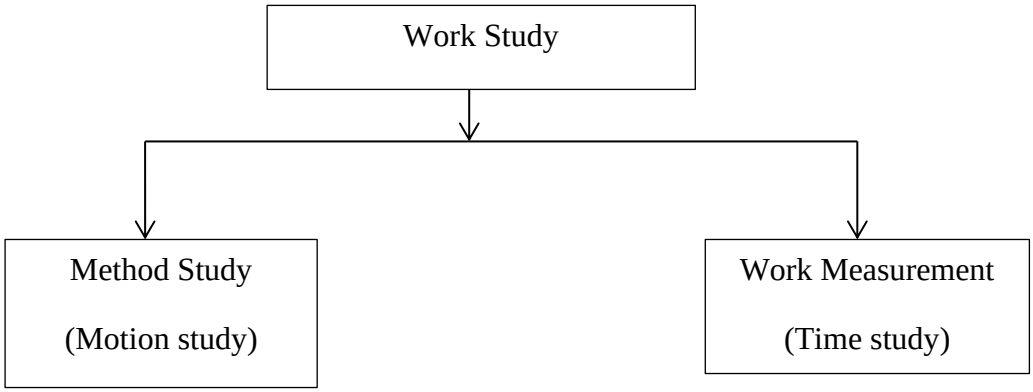


Fig4.1 Work Study

Method study is defined as a systematic recording, analysis and critical examination of existing and proposed ways of doing and development and application of easier and more effective work methods to replace the existing work methods.

Method study is also known as methods analysis or methods engineering or work improvement or work simplification.

Work measurement is the application of techniques designed to measure and establish the work content of a specified task or job by determining the time required for carrying out the task or job by a qualified worker at a defined standard of performance

WORK STUDY PROCEDURE

- **Select** the job or the process or the operation to be studies.
- **Record** all relevant facts about the job or operation using suitable charting techniques such operation process chart, flow process chart, flow diagram, SIMO chart (simultaneous motion chart) and man machine chart
- **Examine** critically all the recorded facts, questioning the purpose, place, sequence, person and the means of doing the job/process/operation.
- **Develop** the new method for the job/process/operation.
- **Measure** the work content and establish the standard time using an appropriate work measurement technique, viz., time study using stop watch, synthesis method, analytical estimating method, pre-determined motion time system and work sampling
- **Define** the new method for the job/process/operation.
- **Install** the new method as standard practice.
- **Maintain** the new method the steps involved in work study.

BENEFITS OF WORK STUDY

- Increased productivity and operational efficiency.
- Reduced manufacturing costs.
- Improved work place layout.
- Better manpower planning and capacity planning.
- Fair wages to employees.
- Better working conditions to employees.
- Improved work flow.
- Reduced material handling costs.
- Provides a standard of performance to measure labour efficiency.

- Better industrial relations and employee morale.
- Basis for sound incentive scheme.
- Provides better job satisfaction to employees.

TIME STUDY

Time study may be defined as the art of observing and recording the time required to do each detailed element of an industrial activity/operation.

OBJECTIVES OF TIME STUDY

a. To furnish a basis of compassion for determining operating effectiveness.
b. To set labour standard for satisfactory performance.
c. To compare alternative methods in method study in order to select the best method.
d. To determine standard costs.
e. To determine equipment and labour requirements.
f. To determine basic times/normal times.
g. To determine the number of machines an operator can handle.
h. To balance the work of operators in production or assembly lines.
i. To provide a basis for setting piece rate or incentive wages.
j. To set the completion schedules for individual operations or jobs.
k. To determine the cycle time for completion of a job.

TIME STUDY BY STOP WATCH

The steps involved are

- Select the job to be studied
- Select the worker to be studied
- Conducting stop watch time study

  A stop watch may be of the following types
  - ✓ Non fly back stop watch is preferred for recording continuous timing
  - ✓ Fly back watch, the watch is started and stopped with the help of the slide.
  - ✓ Split hand type of stop watch gives higher accuracy in reading when two elements are to be timed successively.

HUMAN CONSIDERATION IN WORK STUDY

Work study will be a powerful management tool to improve productivity only if a good relationship is established between the managers, supervisors and employees. Due

consideration should be given to everyone concerned as an individual and should see that no one will perceive a threat to his security and self-respect.

Relationship between work study and people

- **Work Study and the management**

  Work study through the direct observation and analysis if a given situation will show up any short coming in all activities affecting productivity. For example

  - ✓ Idle time due to lack of materials
  - ✓ Frequent breakdown of machine

  Work study analyst has to be very tactful in handling the people and it should be used with care. The support of top management is necessary for a work study analyst to be successful.

- **Work Study and the supervisor**

  The hostile attitude of the supervisor may be the most important aspect since the people take their attitude from their bosses

- **Work Study and the workers**

  The relationship between management and workers has to be reasonably good for success of work study. The workers should have confidence on management. This can be achieved by sound personnel policy of the management.

METHOD STUDY (OR METHOD ANALYSIS)

Method study or method analysis focuses on how a job is done. It is a scientific technique of observing, recording and critically examining the present method of performing a job or task or operation with the aim of improving the present method and developing a new and cheaper method. It is also knows as methods improvement or work improvement.

OBJECTIVES OF METHOD STUDY

- To study the existing / proposed method of doing any job, operation or activity.
- To develop an improved method to improve productivity and to reduce operating costs.
- To reduce excessive material handling or movement and thereby reduce fatigue to workmen.
- To improve utilisation of resources.
- To eliminate wasteful and inefficient motions.
- To standardise work methods or processes, working conditions, machinery, equipment's and tools

STEPS INVOLVED IN METHOD STUDY

The various steps involved in method study are

1. Select

Select the work or job to be studied and define the objectives to be achieved by method study. The job selected to have maximum economic advantage, shall offer vast scope for work improvement through reduction of excessive material handling and fatigue to workmen, offer scope for improving the working conditions and improving the utilization of resources.

2. Record

Record all the relevant facts or information pertaining to the existing method using the recording techniques such as

- ✓ Process charts such as Outline process chart, Operation process chart, Flow process chart, Man-machine chart, two handed process chart, multiple activity chart, Motion chart etc.,
- ✓ Diagrams such as Flow diagram, String diagram, Cycle graph etc.,

3. Examine

Examine the recorded facts critically challenging everything being done and seeking alternatives, questioning the purpose, the means, sequence, place and the person.

4. Develop

Develop the improved method by generating several alternatives and selecting the best method.

The factors to be considered while evaluating alternatives and selecting the best method are cost of implementation, expected savings in time and cost, feasibility, producibility etc.,. Establish the new method by providing suitable equipment design, mechanical aids, jigs and fixtures, tools, working conditions, material handling equipment's, workplace layout and control techniques.

5. Install

Install the improved method in three phases – planning, arranging and implementing phases. In the first two phases, the programme of installation and a schedule are planned and necessary requirements such as resources, equipment's, tools, operating instructions to workers are provided. The implementation phase involves the introduction of the developed method as standard practice to achieve the desired results.

6. Maintain

Maintain the new method by ensuring that the installed method is functioning well. This is done by periodic checks and verification at regular intervals. Proper control procedures are used to ensure that

the new method is practiced to achieve the benefits of methods study and also to achieve higher productivity.

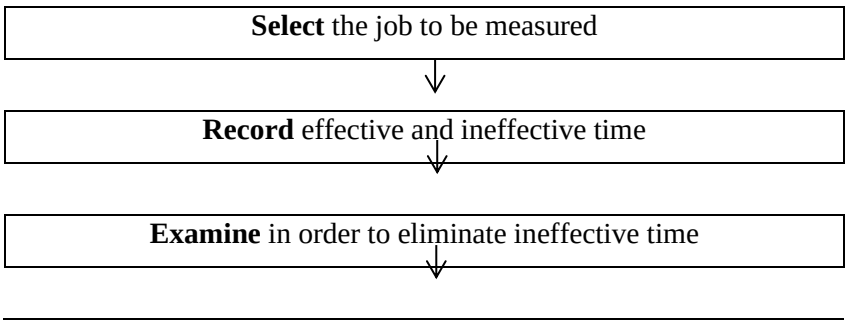
WORK MEASUREMENT

Work measurement is determined as the application of techniques designed to establish the work content of a specified task by determining the time required for carrying out the task at a defined standard of performance by a qualified worker.

OBEJCTIVES OF WORK MEASUREMENT

i. To determine how long it should take to do a job. (time standards reflect the amount of time it should take an average worker or a qualified worker to do a given job under typical conditions).
ii. Improve planning and control of activities or operations.
iii. To compare alternative methods developed by method study in order to establish the work content of each method and thereby select the most economical method.
iv. More efficient manning of the plant i.e., determining the number of employees needed for doing various kinds of jobs in a plant based on the knowledge of the amount of time needed to do each job. The analysis of the idle time and effective time inherent in the performance of each job allows effective allotment of work and also to determine the manpower required.
v. Reliable indices (in terms of standard job times) for evaluating labour performance and to determine labour efficiency.
   Labour efficiency (% ge) = (Standard time / Actual time taken) X 100
vi. Reliable basis for labour cost control (labour cost estimates are based on standard time estimates).
vii. To provide a sound basis for designing incentive schemes.
viii. To provide inputs to scheduling and budgeting (in terms of standard job times)

PROCEDURE OF WORK MEASUREMENT



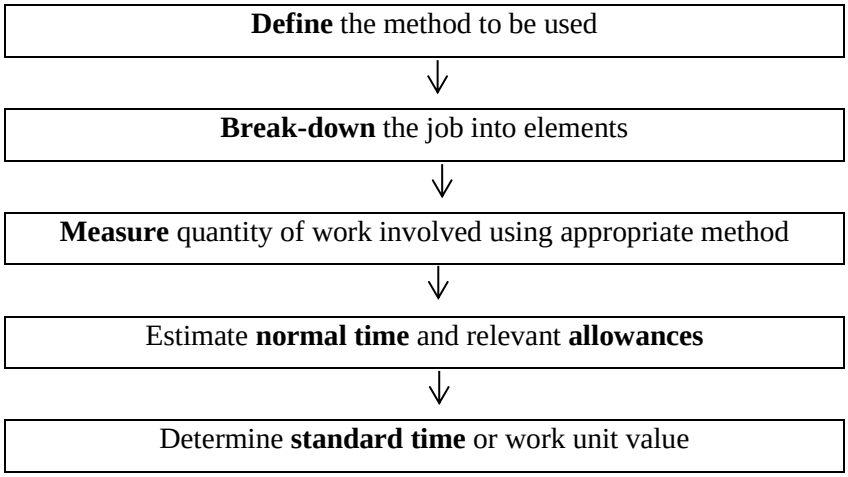


Fig 4.2 Work Measurement procedure

TECHNIQUES OF WORK MEASUREMENT

The main techniques used to measure work are:

1. Direct time study
2. Synthesis method
3. Analytical estimating
4. Pre-determined Motion Time System (PMTS)
5. Work sampling or Activity Sampling or Ratio Delay Method

- **Time Study**

Time study is a work measurement technique for recording the times and rates of working for the elements of a specified job carried out under specified conditions and for analyzing the data so as to obtain necessary for carrying out the job at a defined level of performance.

- **Synthesis Method**

Synthesis is a technique of work measurement for building up the time required to do a job at a defined level of performance by synthesizing or totaling elemental time values obtained from previous time studies on other jobs containing similar job elements or from standard data or synthetic data or build-up time standard.

- **Analytical Estimating**

This technique of work measurement is used to determine the time values for jobs, having long and non-repetitive operations. The time values are determined by using synthetic data or on the basis of the past experience of the work study engineer, when no synthetic or standard data is available.

- **Pre-determined Motion Time System (PMTS)**

Pre-determined Motion Time System is defined as a work measurement technique by which normal or basic times are established for basic human motions and these time values are used to build up the time for a job at a defined level of performance.

PMTS is an improvement over motion study because, besides affording detailed analysis of the motion, it makes it possible to set a measure of the time that a series of motion ought to take.

Types of Predetermined Motion Time System

i. Methods Time Measurement (MTM)
ii. Work Factor
iii. Basic Motion Times (BMT)

- **Work sampling or Activity Sampling or Ratio-Delay Method**

Work sampling is a work measurement technique that randomly samples the work of one or more employees at periodic intervals to determine the proportion of total operation that is accounted for in one particular activity.

COMPUTATION OF STANDARD TIME

Standard time may be defined as the, amount of time required to complete a unit of work: (a) under existing working conditions, (b) using the specified method and machinery, (c) by an operator, able to the work in a proper manner, and (d) at a standard pace.

Determine the standard time by adding the relevant allowance to the normal or basic time.

Standard time = Normal time + All relevant allowances

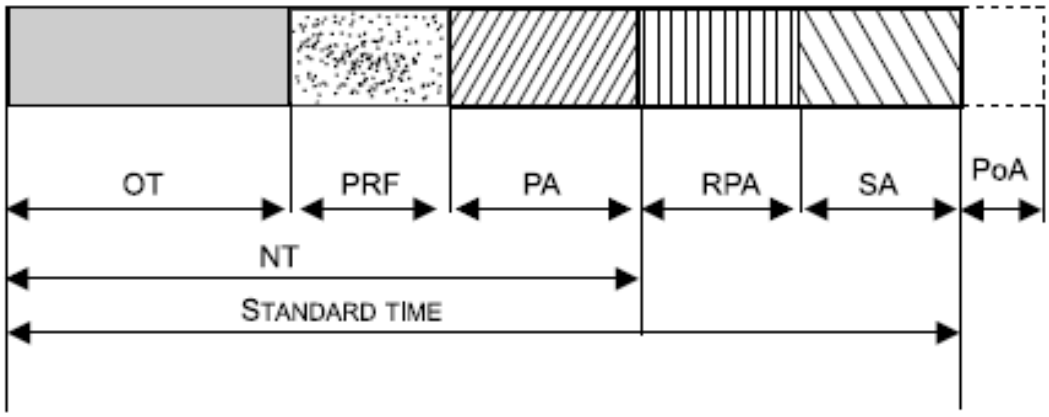


Fig 4.3: Computation of Standard time

OT = Observed time

NT = Normal time

PA = Process Allowance

SA = Special Allowance

AT = Allowance Time

PRF = Performance Rating Factor

BT = Basic Time

POA = Policy Allowance

CA = Contingency Allowance

ST = Standard Time

ALLOWANCE

Allowance can be defined as the extra time figures which are to be added to the basic time of an operation to account for personnel desires, delays, fatigue of operators, any special situation and the policies of the firm or organization.

TYPE OF ALLOWANCES

i. **Relaxation Allowance (RA):** This is also known as personal, fatigue on delay allowance (PFD allowance), this allowance is given to the worker to overcome the fatigue due to physical exertion, posture, concentration, working condition and personal needs such as going to toilet, drinking water, attending phone calls etc. It usually varies from 10% to 20% of normal or basic time.

ii. **Contingency Allowance (CA):** This allowance is given for infrequent or non-repetitive activities such as obtaining special materials from the tool stores, sharpening of tool, getting a special tool from the tool stores and consultation with the supervisor. It is usually about 5% of normal or basic time.

iii. **Process Allowances:** Allowance given to the worker to compensate himself for enforced idleness due to the nature of a process or operation, for e.g., working on automatic machine, electroplating etc., during which the worker is forced to be idle during a part of the work cycle.

iv. Special Allowances:

a) Interference allowance given to a worker when he/she is looking after 2 or 3 machines. One machine may idle when the worker works on another machine for a short period and allowance has to be given to the worker for this loss of production.

b) Periodic activity Allowance – for activities carried out periodically during a work cycle e.g., setting up a tool on the machine.

COMPARISON OF VARIOUS WORK MEASUREMENT TECHNIQUES

Criteria	**Work Sampling**	**Predetermined Time Standard**	**Stop Watch Timing**
1. Speed time required to measure and establish standards	Average to fast	Slow to average	Average
2. Training and Skills required : Technical supervisor	Low to moderate	High	Moderate to high
3. Cost: Training, employee timing, equipment etc.	Average	Fairly high	Average
4. Assistance in Methods Improvements	Low to moderate	High	Good
5. Accuracy: Subjective vs. objective, degree of distortion	Fair to good	Very high	Good to high
6. Acceptability: Employee Supervisor	Fair	Good	Fair to Good
7. Interruption of Work Operations	Moderate	Low	Fairly high
8. Applicability: For physical, clerical, professional work	Very good	Average	Average
9. Savings:	Average to high	High	Average to high

****

PART – A		**CO**	**Blooms Level**
1.	Define Work Study.	CO4	1
2.	State the importance of work study.	CO4	1
3.	Define Time study.	CO4	1
4.	Recall the term ‘Motion Study’.	CO4	1
5.	State the term ‘Work Measurement’.	CO4	1
6.	What do you mean by Fly back watch?	CO4	1
7.	Mention the objectives of Method Study.	CO4	1
8.	Expand PMTS.	CO4	1
9.	What is the formula for standard time?	CO4	1

10.	Define Allowance.	CO4	1

PART – B		CO	Blooms Level
1.	Describe in detail the procedure of work study.	CO4	4
2.	Explain about the human consideration in work study.	CO4	3
3.	Discuss the steps involved in method study.	CO4	3
4.	Elaborate the techniques of work measurement.	CO4	4
5.	Compare the various techniques of work measurement.	CO4	4
6.	Explain in detail the various types of allowances.	CO4	3

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SCHOOL OF MANAGEMENT STUDIES

UNIT – V – Production Management – SBAA1406

UNIT V

INSPECTION

Inspection : Objectives - Functions - Centralized and Decentralized Inspection - Quality Control: Objectives - Advantages - SQC (Statistical Quality Control) :Techniques - Benefits - Control Charts - Advantages - X Chart - R Chart - C Chart - P Chart - Quality Circle - Characteristics - Advantages.

INSEPECTION

Inspection has been defined as a function whose purposes are to interpret specifications, verify conformance to these specifications and communicate the information obtained to those responsible for making necessary corrections in the manufacturing process.

The act of determining conformance or non-conformance of the expected performance is the function of inspection.

Inspection is primarily a comparison with established standards, whereas quality control is concerned with any function which contributes to the quality of goods produced.

OBJECTIVES OF INSPECTION

- The major objective of inspection is the prevention of defects.
- Detect defects as they occur in processing.
- Detect trends in the process which might lead to defects.
- Remove defective parts from production to stop further handling and processing costs.
- Remove defective parts to prevent poor performance of finished product.
- Inform all levels of management on the performance of manufacturing departments or units.
- Provide records for evaluation of individual machine or worker performance.

FUNCTIONS OF INSPECTION

There are several stages or levels at which inspection may be performed. These may be referred to in broad categories as: (i) receiving inspection, (ii) pre-production inspection, (iii) production inspection, (iv) product tests.

i. **Receiving inspection** is the process of examining purchased goods or materials as they are received into the plant. Its primary purpose is to establish whether or not these goods and materials are acceptable (i.e., of good quality). It should be an inspection of quantity as well as quality. Receiving inspection is also known as inwards goods inspection.

ii. **Pre-production inspection***:* This refers to inspection of materials prior to their actual processing or fabrication. This includes first-piece inspection or first-off inspection, inspection of equipment and tooling and pilot batch or pilot-plant operation. The primary purpose of pre-production inspection is to check on the ability of a machine or process to produce parts to specifications.

- ❖ **First-piece inspection***:* refers to the practice in which an operator of a machine/process brings the first part he/she produces on a new setup to an inspector to verify its correctness before he/she proceeds with the rest of the work order. This inspection assures that the tools and equipment have been properly set.

iii. **Production inspection**:

This includes inspection after every operation is completed and the quality characteristics are checked in comparison with quality standards set in the design. Usually 100 percent inspection is done to ensure that no defective item gets into the next stage of production after a certain operation is carried out. Two common forms of production inspection are: (a) **Patrol or floor inspection** and (b) **Centralised inspection.**

iv. **Product tests:**

In addition to inspection of dimensions, appearance and quality characteristics, some inspections are called **functional tests** of individual parts and components or sub-units. These include tests of physical and chemical properties, tests for performance, endurance and efficiency of operation and the like. Functional tests are conducted on finished parts or sub-units or products. This is usually referred to as **product test.**

CENTRALIZED AND DECENTRALIZED INSPECTION

Centralized inspection

Inspection is carried in a central place with all testing equipment; sensitive equipment is housed in air-conditioned area. Samples are brought to the inspection floor for checking. Centralized inspection may locate in one or more places in the manufacturing industry.

Advantages of Centralized inspection

1. Greater degree of inspection due to sensitive equipment.
2. Less number of inspectors and tools.
3. Equipment needs less frequency of recalibration.
4. Cost of inspection is reduced.
5. Unbiased inspection.
6. Supervision of inspectors made possible.
7. No distraction to the inspector.

Disadvantages of Centralized inspection

1. Defects of job are not revealed quickly for prevention.
2. Greater material handling.
3. High cost as products are subjected to production before they are prevented.
4. Greater delay in production.
5. Inspection of heavy work not possible.
6. Production control work is more complicated.
7. Greater scrap.

Floor or Decentralized inspection

In this system, the inspection is performed at the place of production. It suggests the checking of materials in process at the machine or in the production time by patrolling inspectors. These inspectors move from machine to machine and from one to the other work centers. Inspectors have to be highly skilled. This method of inspection minimize the material handling, does not disrupt the line layout of machinery and quickly locate the defect and readily offers field and correction.

Advantages of decentralized inspection

1. Detection of errors of the source reduces scrap and rework.
2. Correction is done before it affects further production, resulting in saving cost of unnecessary work on defective parts.

3. Material handling time is reduced.
4. Job satisfaction to worker as he can't be held responsible for bad work at a later date.
5. Greater number of pieces can be checked than a sample size.
6. Does not delay in production.

Disadvantages decentralized inspection

1. Delicate instruments can be employed.
2. Measuring or inspection equipment have to be recalibrated often as they are subjected to wear or dust.
3. High cost of inspection because of numerous sets of inspections and skilled inspectors.
4. Supervision of inspectors is difficult due to vibration.
5. Pressure on inspector.
6. Possibility of biased inspection because of worker.

QUALITY

The quality of product or service is a customer's perception of the degree to which the product or service meets his or her expectations.

Dimensions of product quality

Some dimensions of product quality are

- ✓ **Performance**: How will the product or service perform and meet the customer's intended use. For example, the speed of a sports car.
- ✓ **Features**: The special characteristics that appeal to customers. For example, the power steering of an automobile.
- ✓ **Reliability**: The likelihood of breakdowns, malfunctions, or need for repairs. Higher the reliability lesser will be the likelihood of breakdowns all malfunctions and better will be the quality of the product.
- ✓ **Serviceability**: The speed, cost and convenience of repairs and maintenance. Higher the serviceability better will be the quality of the product.
- ✓ **Appearance**: The effect or human senses, the look, feel, taste, smell or sound.
- ✓ **Customer service**: The treatment received by customers before, during and after the sale.
- ✓ **Safety**: How well the product protects users before, during and after use.

QUALITY CONTROL

Quality control refers to all those functions or activities that must be performed to fill the company's quality objectives.

OBJECTIVES OF QUALITY CONTROL

1. To improve the companies income by making the production more acceptable to the customers, *i.e.*, by providing long life, greater usefulness, maintainability etc.
2. To reduce companies cost through reduction of losses due to defects.
3. To achieve interchangeability of manufacture in large scale production.
4. To produce optimal quality at reduced price.
5. To ensure satisfaction of customers with productions or services or high quality level, to build customer goodwill, confidence and reputation of manufacturer.
6. To make inspection prompt to ensure quality control.
7. To check the variation during manufacturing.

ADVANTAGES OF QUALITY CONTROL

- Improving the quality of products and services.
- Increasing the productivity of manufacturing processes, commercial business, and corporations.
- Reducing manufacturing and corporate costs.
- Determining and improving the marketability of products and services.
- Reducing consumer prices of products and services.
- Improving and/or assuring on time deliveries and availability.
- Assisting in the management of an enterprise.

STATISTICAL QUALITY CONTROL(SQC)

The statistical quality control is a field that dates back to the 1920s. Dr. Walter A. Shewhart of the Bell Telephone Laboratories was one of the early pioneers of the field. In 1924, he wrote a memorandum showing a modern control chart, one of the basic tools of statistical process control. Harols. F. Dodge and Harry G. Roming two other Bell System employees, provided much of the leadership in the development of statistically based sampling and inspection methods. The work of these 3 men forms much of these methods to U.S. industry. Dr. W. Edwards Deming and Dr. Joseph M. Juran have been instrumental in spreading statistically quality-control methods since World war II. The Japanese have been particularly

successful in deploying statistical quality-control methods and have used statistical methods to gain significant advantage over their competitors

Statistical quality control, the use of statistical methods in the monitoring and maintaining of the quality of products and services.

One method, referred to as **acceptance sampling**, can be used when a decision must be made to accept or reject a group of parts or items based on the quality found in a sample.

A second method, referred to as **statistical process control**, uses graphical displays known as control charts to determine whether a process should be continued or should be adjusted to achieve the desired quality.

ACCEPTANCE SAMPLING

Acceptance sampling is a technique in which it is based on the inspection of a small sample the decision regarding accepting and rejecting a lot is taken. It is assumed that the sample represents the whole of lot.

It is assumed that the sample is chosen in random or unbiased manner

STATISTICAL PROCESS CONTROL

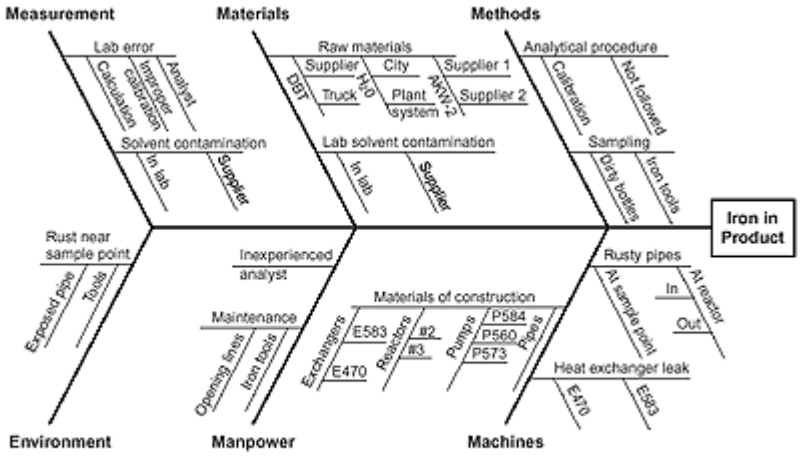
It is impractical to inspect quality into a product. The product must be built right the first time. The manufacturing process must therefore be stable and repeatable and capable of operating with little variability around the target or nominal dimension. Online statistical process control is a powerful tool for achieving process stability and improving capability through the reduction of variability. It is customary to think of Statistical process control(SPC) as a set of problem solving tools that may be applied to any process.

TECHNIQUES OF STATISTICAL QUALITY CONTROL

In 1974, Dr. Kaoru Ishikawa brought together a collection of process improvement tools in his text Guide to Quality Control. Known around the world as the seven quality control (7-QC) tools, they are:

1. **Cause-and-effect diagram** (also called Ishikawa diagram or fishbone diagram)

Ishikawa diagrams (also called fishbone diagrams, herringbone diagrams, cause-and-effect diagrams, or Fishikawa) are causal diagrams created by Kaoru Ishikawa that show the causes of a specific event. Common uses of the Ishikawa diagram are product design and quality defect prevention to identify potential factors causing an overall effect. Each cause or reason for imperfection is a source of variation. Causes are usually grouped into major categories to identify and classify these sources of variation



Fishbone Diagram Example

2. Check sheet

A check sheet is a structured, prepared form for collecting and analyzing data. This is a generic data collection and analysis tool that can be adapted for a wide variety of purposes and is considered one of the seven basic quality tools.

Telephone Interruptions

Reason	Day					
	Mon	Tues	Wed	Thurs	Fri	Total
Wrong number	𝍸	||	|	𝍸	𝍸 ||	20
Info request	||	||	||	||	||	10
Boss	𝍸	||	𝍸 ||	|	|||	19
Total	12	6	10	8	13	49

Check Sheet Example

3. Control chart

The control chart is a graph used to study how a process changes over time. Data are plotted in time order. A control chart always has a central line for the average, an upper line for the upper control limit, and a lower line for the lower control limit. These lines are determined from historical data. By comparing current data to these lines, you can draw conclusions about whether the process variation is consistent (in control) or is unpredictable

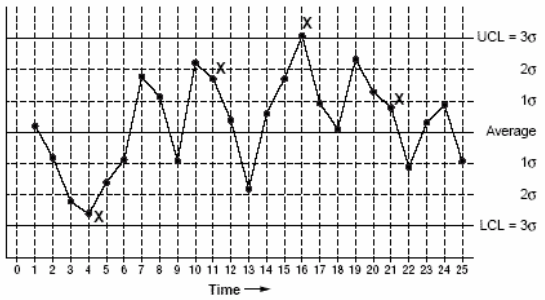
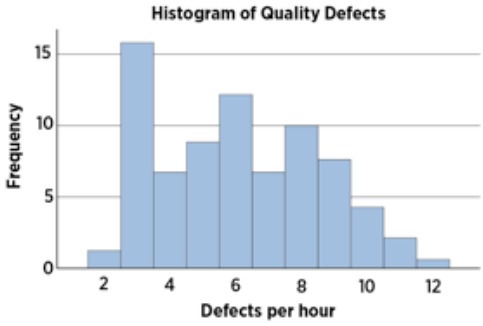


Figure 1 Control Chart: Out-of-Control Signals

4. Histogram

A frequency distribution shows how often each different value in a set of data occurs. A histogram is the most commonly used graph to show frequency distributions. It looks very much like a bar chart, but there are important differences between them



Histogram Example

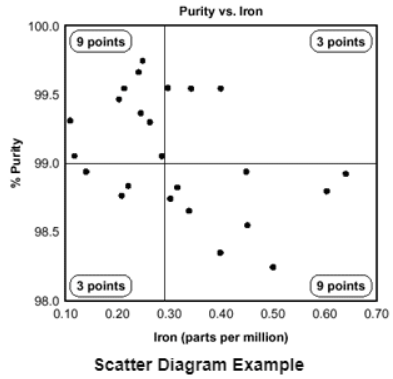
5. Pareto chart

A Pareto chart is a bar graph. The lengths of the bars represent frequency or cost (time or money), and are arranged with longest bars on the left and the shortest to the right. In this way the chart visually depicts which situations are more significant.

Figure 1: Pareto Chart, Customer Complaints

6. Scatter diagram

The scatter diagram graphs pairs of numerical data, with one variable on each axis, to look for a relationship between them. If the variables are correlated, the points will fall along a line or curve.



Scatter Diagram Example

7. Stratification

Stratification is defined as the act of sorting data, people, and objects into distinct groups or layers. It is a technique used in combination with other data analysis tools. When data from a variety of sources or categories have been lumped together, the meaning of the data can be difficult to see.

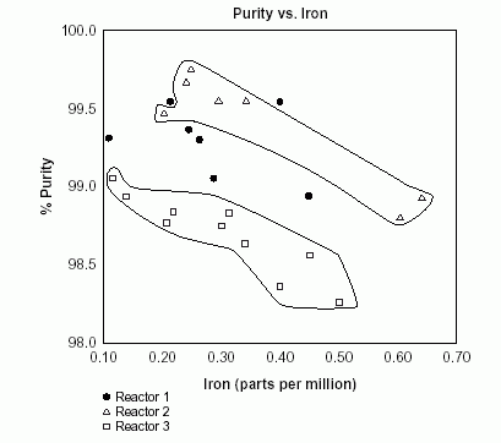


Figure 1: Stratification Diagram

BENEFITS OF SQC

- It involves inspection of only a fraction of items produced in a fixed period. Hence it is very economical.
- The inspection of each and every item has hardly been feasible, as the rate of production in many cases will be faster than the time required for the inspection of items. Hence, 100 per cent inspection would cost too much. Also, in cases where the unit is destroyed during inspection, 100 percent inspection is impossible.
- The inspection of each and every unit will reduce efficiency of the quality inspectors
- SQC can be carried out by persons who do not possess a high degree in engineering or statistics.
- SQC keeps consistent vigilance on the quality of the product.
- Variation is inherent and unavoidable
- Process control provides the basis to the producer, for deciding about the specifications.
- SQC enables the manufacturers to know whether the changes brought in the production by installing new machines or by changing the system of the process or by employing more skilled persons has improved the quality of the product or not.

CONTROL CHARTS

The control chart is a graph used to study how a process changes over time. Data are plotted in time order. A control chart always has a central line for the average, an upper line for the upper control limit, and a lower line for the lower control limit. These lines are determined from historical data.

CHARACTERISTICS OF CONTROL CHARTS

A control chart is a time-ordered diagram to monitor a quality characteristic, consisting of:

1. A nominal value, or centre line, the average of several past samples.
2. Two control limits used to judge whether action is required, an upper control limit (UCL) and a lower control limit (LCL).
3. Data points, each consisting of the average measurement calculated from a sample taken from the process, ordered overtime. By the Central Limit Theorem, regardless of the distribution of the underlying individual measurements, the distribution of the sample means will follow a normal distribution. The control limits are set based on the sampling distribution of the quality measurement.

ADVANTAGES OF CONTROL CHARTS

Following are the benefits of control charts:

1. A control chart indicates when something may be wrong, so that corrective action can be taken.
2. The patterns of the plot on a control chart diagnosis possible cause and hence indicate possible remedial actions.
3. It can estimate the process capability of process.
4. It provides useful information regarding actions to take for quality improvement.

OBJECTIVES OF CONTROL CHARTS

Following are the objectives of control charts:

1. To secure information to be used in establishing or changing specifications or in determining whether the process can meet specifications or not.
2. To secure information to be used on establishing or changing production procedures.
3. To secure information to be used on establishing or changing inspection procedures or acceptance procedures or both.
4. To provide a basis for current decision during production.
5. To provide a basis for current decisions on acceptance for rejection of manufacturing or purchased product.
6. To familiarize personnel with the use of control chart.

TYPES OF CONTROL CHARTS

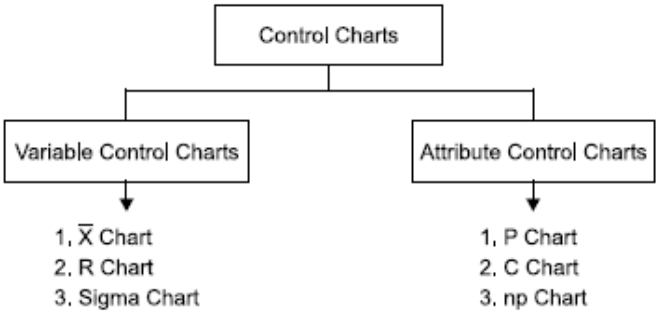


Fig : Control charts

CONTROL CHARTS FOR VARIABLES

As the name indicates, these charts will use variable data of a process. X chart given an idea of the central tendency of the observations. These charts will reveal the variations between sample observations. R chart gives an idea about the spread (dispersion) of the observations. This chart shows the variations within the samples.

X-Chart and R-Chart: The formulas used to establish various control limits are as follows:

a. Standard Deviation of the Process, σ, **Unknown** R-Chart: To calculate the range of the data, subtract the smallest from the largest measurement in the sample the control limits

The control limits are: $UCL_R = D_4\bar{R}$ and $LCL_R = D_3\bar{R}$

where $\bar{R}$ = average of several past R values and is the central line of the control chart, and

D_3, D_4 = constants that provide three standard deviation (three-sigma) limits for a given sample size

$\bar{X}$-Chart: The control limits are:

$$UCL_{\bar{X}} = \bar{\bar{X}} + A_2\bar{R} \text{ and } LCL_{\bar{X}} = \bar{\bar{X}} - A_2\bar{R}$$

where $\bar{\bar{X}}$ = central line of the chart and the average of past sample mean's, and

A_2 = constant to provide three-sigma limits for the process mean.

b. Standard Deviation of the Process, σ, **Known Control charts** for variables (with the standard deviation of the process, σ, known) monitor the mean, X , of the process distribution. The control limits are:

$$UCL = \overline{\overline{X}} + 2\sigma_{\overline{x}}$$

and $$LCL = \overline{\overline{X}} - 2\sigma_{\overline{x}}$$

where $\overline{\overline{X}}$ = centre line of the chart and the average of several past sample means, Z is the standard normal deviate (number of standard deviations from the average),

$\sigma_{\overline{x}} = \sigma/\sqrt{n}$ and is the standard deviation of the distribution of sample means, and n is the sample size

Procedures to construct X-chart and R-chart

1. Identify the process to be controlled.
2. Select the variable of interest.
3. Decide a suitable sample size (n) and number of samples to be collected (k).
4. Collect the specified number of samples over a given time interval.
5. Find the measurement of interest for each piece within the sample.
6. Obtain mean (X) of each sample.
7. Establish control limits for X and R-charts.

CONTROL CHARTS FOR ATTRIBUTES

P-charts and C-charts are charts will used for attributes. This chart shows the quality characteristics rather than measurements.

P-CHART

A p-chart is a commonly used control chart for attributes, whereby the quality characteristic is counted, rather than measured, and the entire item or service can be declared good or defective. The standard deviation of the proportion defective, p, is:

$\sigma_p = \sqrt{\overline{p}(1-\overline{p})/n}$, where n = sample size, and $\overline{p}$ = average of several past p values and central line on the chart.

Using the normal approximation to the binomial distribution, which is the actual distribution of p,

$$UCL_p = \overline{p} + Z\sigma_p$$

and $$LCLp = \overline{p} - Z\sigma_p$$

where z is the normal deviate (number of standard deviations from the average).

PROBLEMS

ILLUSTRATION 1: *Several samples of size n = 8 have been taken from today's production of fence posts. The average post was 3 yards in length and the average sample range was 0.015 yard. Find the 99.73% upper and lower control limits.*

SOLUTION:

$\overline{\overline{X}} = 3$ yds

$\overline{R} = 0.015$ yds

$A_2 = 0.37$ from Statistical Table

$UCL = \overline{\overline{X}} + A_2\overline{R} = 3 + 0.37(0.015) = 3.006$ yds

$LCL = \overline{\overline{X}} - A_2\overline{R} = 3 - 0.37(0.015) = 2.996$ yds

ILLUSTRATION 2 (*Problem on $\overline{X}$ and R Chart*): *The results of inspection of 10 samples with its average and range are tabulated in the following table. Compute the control limit for the $\overline{\overline{X}}$ and R-chart and draw the control chart for the data.*

Sample No. (*Sample Size 5*)	$\overline{\overline{X}}$ (*Mean*)	*R (Range)*
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
	$\Sigma\overline{\overline{X}} = 76$	$\Sigma R = 26$

SOLUTION:

$$\overline{\overline{X}} = \Sigma \overline{\overline{X}} / \text{No. of samples}$$

$$\overline{R} = \Sigma R / \text{No. of samples}$$

Therefore,

$$\overline{\overline{X}} = \frac{76}{10} = \mathbf{7.6}$$

$$\overline{R} = \frac{26}{10} = \mathbf{2.6}$$

For $\overline{\overline{X}}$ chart

Upper Control Limit (UCL) $= \overline{\overline{X}} + A_2 \overline{R}$

Lower Control Limit (LCL) $= \overline{\overline{X}} - A_2 \overline{R}$

For $\overline{R}$ chart

Upper Control Limit (UCL) $= D_4 \overline{R}$

Lower Control Limit (LCL) $= D_3 \overline{R}$

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

$$A_2 = 0.58,\ D_3 = 0 \text{ and } D_4 = 2.11$$

Thus, for $\overline{\overline{X}}$ chart

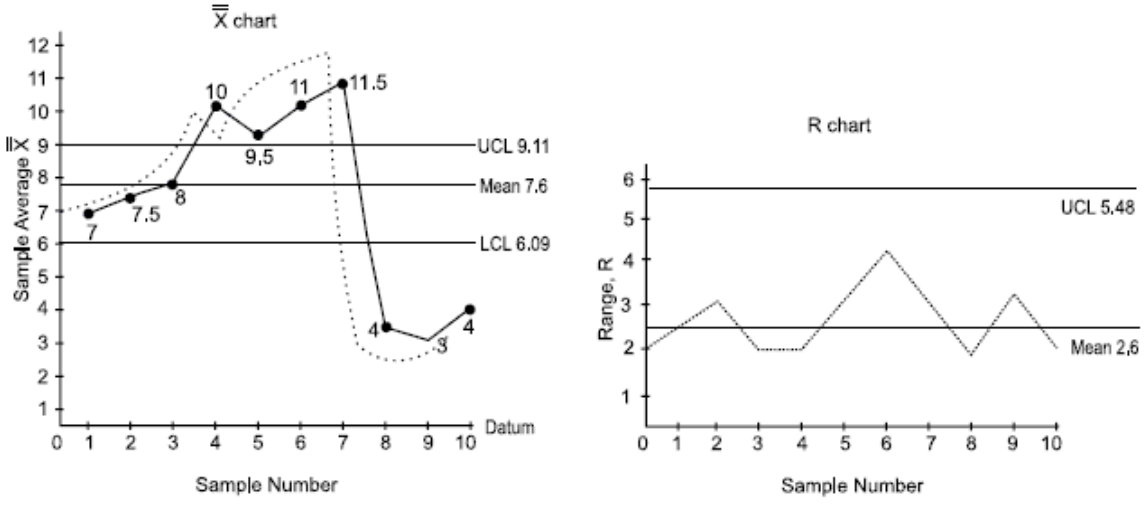
$$UCL = 7.6 + (0.58 \times 2.6)$$
$$= 7.6 + 1.51 = \mathbf{9.11}$$
$$LCL = 7.6 - (0.58 \times 2.6) = \mathbf{6.09}$$

For R chart

$$UCL = 2.11 \times 2.6 = \mathbf{5.48}$$
$$LCL = D_3 \times \overline{R} = 0 \times \overline{R} = \mathbf{0}$$

These control limits are marked on the graph paper on either side of the mean value (line). $\overline{\overline{X}}$ and R values are plotted on the graph and jointed, thus resulting the control chart.

From the $\overline{\overline{X}}$ chart, it appears that the process became completely out of control for 4th sample over labels.



(ii) Standard Deviation of the Process, σ, known

ILLUSTRATION 3: *Twenty-five engine mounts are sampled each day and found to have an average width of 2 inches, with a standard deviation of 0.1 inche. What are the control limits that include 99.73% of the sample means (z = 3)?*

SOLUTION:

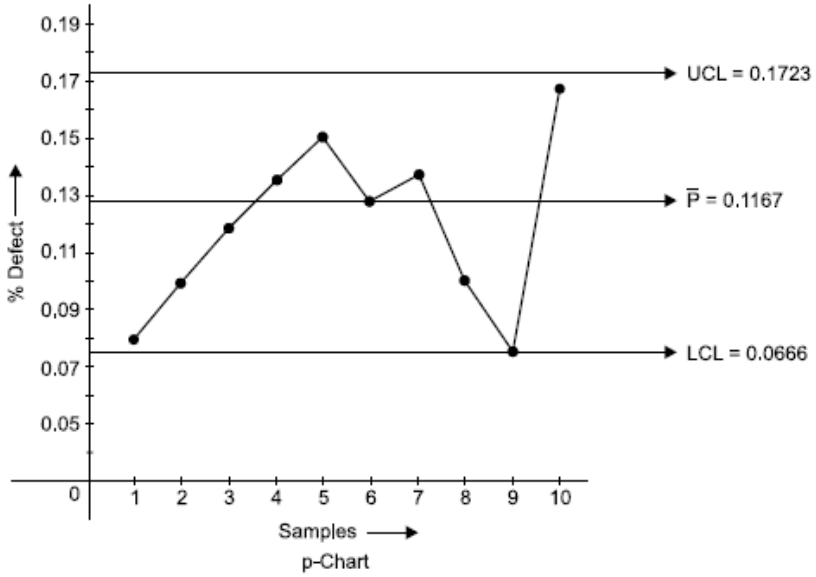
$$UCL_{\bar{X}} = \overline{\overline{X}} + Z\sigma_{\bar{X}} = 2 + 3\left(0.1/\sqrt{25}\right) = 2 + 0.06 = 2.06 \text{ inches}$$

$$LCL_{\bar{X}} = \overline{\overline{X}} - Z\sigma_{\bar{X}} = 2 - 3\left(0.1/\sqrt{25}\right) = 2 - 0.06 = 1.94 \text{ inches}$$

ILLUSTRATION 4 ***(Problem on p-Chart)***: *The following are the inspection results of 10 lots, each lot being 300 items. Number defectives in each lot is 25, 30, 35, 40, 45, 35, 40, 30, 20 and 50. Calculate the average fraction defective and three sigma limit for P-chart and state whether the process is in control.*

SOLUTION:

Date	*Number of pieces inspected* (*a*)	*Number of defective pieces found* (*b*)	*Fraction defective p = (b)/(a)*	*% Defective loop*
November 4	300	25	0.0834	8.34
November 5	300	30	0.1000	10.00
November 6	300	35	0.1167	11.67
November 7	300	40	0.1333	13.33
November 8	300	45	0.1500	15.00
November 10	300	35	0.1167	11.67
November 11	300	40	0.1333	13.33
November 12	300	30	0.1000	10.00
November 13	300	20	0.0666	6.66
November 14	300	50	0.1666	16.66
Total Number = 10	3000	350		



$$\text{Upper Control Limit, UCL} = \bar{p} + 3\sqrt{\frac{\bar{P}\left(1-\bar{P}\right)}{n}}$$

$$\text{Lower Control Limit, LCL} = \bar{p} - 3\sqrt{\frac{\bar{P}\left(1-\bar{P}\right)}{n}}$$

where $$\bar{p} = \frac{\text{Total number of defective pieces found}}{\text{Total number of pieces inspected}}$$

$$\bar{p} = \frac{350}{3000} = \mathbf{0.1167}$$

and $$n = \text{number of pieces inspected every day} = 300$$

Therefore, $$\sqrt{\frac{\bar{p}\left(1-\bar{p}\right)}{n}} = \sqrt{\frac{0.1167 \times (1-0.1167)}{300}}$$

$$= \sqrt{\frac{0.1167 \times 0.8333}{300}} = \mathbf{0.01852}$$

and $$3.\sqrt{\frac{\bar{p}\left(1-\bar{p}\right)}{n}} = 0.01852 \times 3 = \mathbf{0.05556}$$

Thus, $$\text{UCL} = 0.1167 + 0.05556 = 0.17226 = 0.1723 \text{ (Approx.)}$$
$$\text{LCL} = 0.1167 - 0.05566 = 0.06114 = 0.0611 \text{ (Approx.)}$$

P-Chart Example: A production manager for a tire company has inspected the number of defective tires in five random samples with 20 tires in each sample. The table below shows the number of defective tires in each sample of 20 tires. Calculate the control limits.

Sample	Number of Defective Tires	Number of Tires in each Sample	Proportion Defective
1	3	20	**.15**
2	2	20	**.10**
3	1	20	**.05**
4	2	20	**.10**
5	1	20	**.05**
Total	9	100	**.09**

Solution:

$$CL = \bar{p} = \frac{\#\text{Defectives}}{\text{Total Inspected}} = \frac{9}{100} = .09$$

$$\sigma_p = \sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = \sqrt{\frac{(.09)(.91)}{20}} = 0.064$$

$$UCL_p = \bar{p} + z(\sigma) = .09 + 3(.064) = .282$$

$$LCL_p = \bar{p} - z(\sigma) = .09 - 3(.064) = -.102 = 0$$

C-Chart Example: The number of weekly **customer complaints** are monitored in a large hotel using a c-chart. Develop **three sigma control limits** using the data table below.

Week	Number of Complaints
1	3
2	2
3	3
4	1
5	3
6	3
7	2
8	1
9	3
10	1
Total	22

Solution:

$$CL = \frac{\#\text{complaints}}{\#\text{of samples}} = \frac{22}{10} = 2.2$$

$$UCL_c = \bar{c} + z\sqrt{\bar{c}} = 2.2 + 3\sqrt{2.2} = 6.65$$

$$LCL_c = \bar{c} - z\sqrt{\bar{c}} = 2.2 - 3\sqrt{2.2} = -2.25 = 0$$

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QUALITY CIRCLE

A quality circle has been defined as a self-governing group of workers with or without their supervisors who voluntarily meet regularly to identify, analyse and solve problems f their work field.

Quality circle is a group of employees belonging to the same areas, who continuously work towards the improvement and the development of the organisation

CHARACTERISTICS OF QUALITY CIRCLE

- It is voluntary group pf employees. Members join circle on their own. There is no pressure from management.
- Size of a quality circle varies between six to ten. Members generally hail from a particular work area.
- Members meet at a periodic intervals to discuss quality related problems.
- Each circle has its own agenda. It has its own terms of reference, select its own problems and offers recommendations for solving them.
- The quality circle, by its very nature, exists to identify, analyse and solve quality related problems.

ADVANTAGES OF QUALITY CIRCLE

(a) They focus on product quality in a planned way.

(b) They train employees to identify their problems, find solutions and implement them without seeking the advice of technical experts.

(c) They satisfy members' higher-order needs of recognition and self-actualisation.

(d) They improve members' participation in work-related problems and enhance their job satisfaction.

(e) They promote productivity, efficiency, cost reduction, design, testing, safety etc. of the products.

(f) Since teaching is done in an informal way, employees are not burdened with analysing and solving their problems. Rather, they feel motivated to offer suggestions to management.

****

	PART – A	CO	Blooms Level
1.	Define inspection.	CO5	1
2.	State the objectives of inspection.	CO5	1
3.	What do you mean by centralized inspection?	CO5	1
4.	List some advantages of decentralized inspection.	CO5	1
5.	State the dimensions of quality.	CO5	1
6.	Define Quality control.	CO5	1
7.	Mention the advantages of quality control.	CO5	1
8.	Define Statistical Quality control	CO5	1
9.	Write the formula for p chart.	CO5	2
10.	What do you mean by Pareto diagram?	CO5	1

<table>
<tr><th colspan="2">PART – B</th><th>CO</th><th>Blooms Level</th></tr>
<tr><td>1.</td><td>Elaborate the various techniques of Statistical Quality control</td><td>CO5</td><td>3</td></tr>
<tr><td>2.</td><td>Discuss in detail about centralized and decentralized inspection</td><td>CO5</td><td>2</td></tr>
<tr><td>3.</td><td>Explain the various types of Control charts.</td><td>CO5</td><td>3</td></tr>
<tr><td>4.</td><td>Discuss about X chart and R chart with its suitable formula.</td><td>CO5</td><td>2</td></tr>
<tr><td>5.</td><td>The results of inspection of 10 samples with its average and range are tabulated in the following table. Compute the control limit for $\overline{X}$ and R chart and draw the control chart for the deta
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<tr><td>4</td><td>11.0</td><td>4</td></tr>
<tr><td>5</td><td>8.0</td><td>3</td></tr>
<tr><td>6</td><td>7.8</td><td>3</td></tr>
<tr><td>7</td><td>4.5</td><td>2</td></tr>
<tr><td>8</td><td>5.0</td><td>2</td></tr>
<tr><td>9</td><td>5.0</td><td>2</td></tr>
<tr><td>10</td><td>8.0</td><td>3</td></tr>
</table></td><td>CO5</td><td>5</td></tr>
<tr><td>6.</td><td>The numbers of weekly customer complaints are monitored in large retail stores using a c-chart. Develop three sigma control limits using the data table below.
<table>
<tr><th>Week</th><th>Number of Complaints</th></tr>
<tr><td>1</td><td>3</td></tr>
<tr><td>2</td><td>2</td></tr>
<tr><td>3</td><td>1</td></tr>
<tr><td>4</td><td>3</td></tr>
<tr><td>5</td><td>3</td></tr>
</table></td><td>CO5</td><td>5</td></tr>
</table>

	6 | 2 7 | 2 8 | 1 9 | 1		
7.	Elaborate in detail about Quality Circle	CO5	3
8.	The following are the inspection results of 10 lots being 400 items. Number defectives in each lot are 30, 25, 40, 40, 35, 45, 30, 20, 10, 40. Calculate the average fraction defective and three sigma limits for p-chart and state whether the process is in control.	CO5	5

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