Production Planning and Control
This book is a part of the course by Jaipur National University, Jaipur. This book contains the course content for Production Planning and Control.

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<td>Bill of Materials</td>
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<td>Economic Order Quantity</td>
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<td>Maintenance Prevention</td>
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<td>Master Product Schedule</td>
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Chapter I
Production Planning and Control

Aim
The aim of this chapter is to:

• analyse the impact of Industrial Revolution on production process
• explain the meaning of production management and planning
• explore production planning and control procedures

Objectives
The objectives of this chapter are to:

• elucidate objectives of production planning control
• understand functions of production planning and control
• enlist the factors that affect production planning and control

Learning outcome
At the end of this chapter, the students are expected to understand:

• meaning of production management and production planning
• production planning and control procedures
• factors affecting production planning and control
1.1 Introduction

In any manufacturing enterprise, production is the driving force to which most of the other functions react. This is particularly true with inventories; they exist because of the needs of production. This chapter stresses on the relationship of production planning and control to work-in-process inventories. Production is the core activity of the industrial organisation and all other activities revolve around this activity.

Manufacturing or production is a process of converting raw materials into finished products to satisfy the needs of the members of the society. Such finished goods may be used for manufacturing other, more complex products, such as aircraft, household appliances or automobiles, or sold to wholesalers, who in turn sell them to retailers, who then sell them to end users – the “consumers.” Most of the production activities are aimed at serving the needs of the local population.

1.2 Production Management and Production Planning

A few terms and definitions

- **Harding H. A.**: Production is concerned with those processes which convert the inputs into outputs. The inputs are various resources like raw materials, men, machines, methods etc. and the outputs are goods and services.
- **Brech E. L.**: Production is a process of effective planning and regulating the operations of that section of an enterprise which is responsible for the actual transformation of materials into finished products.
- **Harry MJS**: The word of production is often used to mean the same as manufacture. In order to go through the process of manufacturing itself, three basic things needed are:
  - someone to do the job
  - his equipment
  - necessary materials

"To run production we need service activities which make sure that the manufacturing activity can go on and control to make sure that it goes in the right direction."

- **Buffa E.S.**: Production deals with decision making related to production processes so that the resulting goods or services are produced according to specifications, in amounts and by the schedule demanded at minimum cost.
- Production refers to the application of management principles to the production function in the factory. In other words, it involves application of planning, organising, directing and controlling to the production process.
- Thus production is the process of bringing together men, materials and machines for producing goods and services desired by the society to satisfy the wants of the people.

1.3 Impact of Industrial Revolution on Production Process

As a result of Industrial Revolution, the factory system came into existence; mass production and specialisation became common to all. Adam Smith was the first person to apply the concept of production economics to the factory system in his book “The Wealth of Nations” (in 1776). Gradually, people came to know the advantages of large-scale production; the role of division of labour in improving quantity and quality of goods and services produced. Adam Smith emphasised that division of labour generates the following benefits:

- as a worker works continuously on the same job, he/she attains higher skills and dexterity.
- it saves time required for changing from one job to another.
- workmen specialised in certain tasks may suggest improvement in existing production methods.

The concept of division of labour led to the development of several other production related concepts.

1.4 Objectives of Production Planning Control

The ultimate objective of production planning and control, like that of all other manufacturing controls, is to contribute to the profits of the enterprise. As with inventory management and control, this is accomplished by keeping the customers satisfied with meeting of the delivery schedules.
Specific objectives of production planning and control are to establish routes and schedules for work that will ensure the optimum utilisation of materials, workers, and machines and to provide the means for ensuring the operation of the plant is in accordance with these plans.

1.5 Production Planning and Control Functions

All four basic phases of control of manufacture are easily identified in production planning and control. The plan for the processing of materials through the plant is established by the functions of process planning, loading, and scheduling. The function of dispatching puts the plan into effect; that is, operations are started in accordance with the plant.

- **Process planning**: The determination of where each operation on a component part, subassembly, or assembly is to be performed results in a route for the movement of a manufacturing lot through the factory. Prior determination of these routes is the job of the manufacturing engineering function.

- **Loading**: Once the route has been established, the work required can be loaded against the selected machine or workstation. The total time required to perform the operation is computed by multiplying the unit operation times given on the standard process sheet by the number of parts to be processed. This total time is then added to the work already planned for the workstation. This is the function of loading, and it results in a tabulated list or chart showing the planned utilisation of the machines or workstations in the plant.

- **Scheduling**: Scheduling is the last step of planning functions. It determines when an operation is to be performed, or when work is to be completed; the difference lies in the detail of the scheduling procedure. In a centralised control situation—where all process planning, loading and scheduling for plan are done in a central office—the details of the schedule may specify the starting and finishing time for an operation.

- **Combining functions**: While it is easy to define “where” as process planning, “how much work” as loading, and “when” as scheduling, in actual operations these three functions are often combined and performed concurrently. How far in advance route, loads, and schedules should be established always presents an interesting problem. The objectives can be approached if the amount of work schedule for the factory or department is equal to or slightly greater than the manufacturing cycle.

- **Dispatching**: Authorising the start of an operation on the shop floor is the function of dispatching. This function may be centralised or decentralised. Again using the machine-shop example, the department dispatched would authorise the start of each of the three machine operation—three dispatch actions based on the foreman’s routing and scheduling of the work through his department. This is decentralised dispatching.

- **Reporting or follow-up**: The manufacturing activity of a plant is said to be “in control” when the actual performance is within the objectives of the planned performance. When tasks are started and completed on schedule, there should be very little, if any, concern about the meeting of commitments. Optimum operation of the plant, however, is attained only if the original plan has been carefully prepared to fully utilise the manufacturing facilities.

- **Corrective action**: This is a keystone of any production planning and control activity. A plant in which all manufacturing activity runs on schedule in all probability is not being scheduled to its optimum productive capacity. With an optimum schedule, manufacturing delays are the rule, not an exception.

- **Re-planning**: Re-planning is not a corrective action. It revises routes, loads, and schedules; and a new plan is developed. This is often required in manufacturing process. Changes in market conditions, manufacturing methods, or many other factors affecting the plant often indicate that a new manufacturing plan is needed.

1.6 Production Planning and Control Procedures

A brief view of all the techniques and procedures of production planning and control is as given below:

- **Production planning and control systems**: Because production planning and control places an emphasis on the control of work-in-process, the system will in effect tie together all previous records and forms developed in all planning for the manufacturing of the product.
• **Market forecast**: Its value to production planning and control is that it will indicate future trends in demand for manufactured product. Work shift policies, plans for an increase or decrease in manufacturing activity, or possible plant expansions may often be based upon the market forecasts and in turn affect the planning of the production planning and control group.

• **Sales order**: This is the second of the five classes of orders. It is a rewrite of the customer’s order specifying what has been purchased – product and quantity and authorising shipment of the goods to the customer. Multiple copies are prepared and all interested functions are furnished a copy. Sales order may be written by marketing, inventory control, or production control.

• **Stock order**: This third class of order is not always used. In the preceding paragraph we indicated how it may be used after sales order accumulate to an economical manufacturing lot. It is, of course, the principal order when manufacturing the stock. It will authorise production in anticipation of future sales.

• **Shop order**: This fourth class of order deals with the manufacture of component parts. Customer, sales and stock orders are for the finished product. In the preceding chapters we discussed how, by product explosion, the requirements are established for component parts to build assembled products.

• **Standard process sheet**: This form is prepared by process engineering and it is the source of basic data as to the type of machine to be used, the time required for processing and the sequence of operations in the manufacture of the product. Routing and scheduling of shop orders, as well as loading of workstations in advance of scheduling, depend on up-to-date standard process sheets being available to the production planning and control group.

• **Engineering specifications**: Blueprints and bills of materials are used by production planning and control when they become a component part of the packaged instructions issued to the shop owner through the control office. One good planning procedure is to accumulate all necessary data for a shop order in a single package – the standard process sheet, the blueprint, the bill of material (if an assembly operation is involved), the route sheet, and possibly the schedule for the production of the order.

• **Route sheet**: This is the form on which the route of a shop order is indicated. In practice, this form is generally combined with one of the other forms in the system. For example, the shop order, the standard process sheet, and the route sheet are often one piece of paper- usually called the shop order or the manufacturing order.

• **Load charts**: These charts are prepared to show the productive capacity that has been “sold” – and at the same time the available productive capacity. These charts may be prepared for each workstation or machine in the plant, or they may be for groups of machines or departments.

• **Job tickets**: This is the fifth and last type of order in a manufacturing situation. Job tickets authorise the performance of individual operations in the manufacturing process.

• **Project planning methods**: The production planning and control methods discussed thus far in this chapter deal primarily with the production of consumer or industrial products which could be considered to fall within the area of “repetitive manufacturing”. The products to be produced are often manufactured in quantities of more than one, and their total processing time can be measured in hours, or at most, days.

The best-known methods that have been developed are CPM (for Critical Path Method) and PERT (for Program Evaluation and Review Technique). The original PERT technique is now considered, more accurately, PERT TIME, whereas a later development is known as PERT COST.

From the optimistic, most likely and pessimistic times, the expected elapsed time \( (t_e) \) can be obtained by statistical techniques. The relationship of the three estimates to the expected elapsed time is given by the formula:

\[
\frac{a+4m+b}{6}
\]

Where,

\( a \) = optimistic time

\( m \) = most likely time.

It can be seen from the formula that the most likely time estimate is given four times as much weight as the optimistic and pessimistic estimates when computing the expected time.

• **System analysis**: As with other manufacturing control system and procedures, production planning and control lends itself to modern mechanization techniques such as machine accounting and use of computers.
1.7 Factors affecting Production Planning And Control

Following are the factors affecting production planning and control:

Type of product

- Again, it is complexity of the products this is important, not what the product is, except as this may in turn relate to the market being served.
- Production control procedures are much more complex and involve many more records in the manufacture of large steam turbine generator sets or locomotives to customer orders than in the production of large quantities of a standard product involving only a few component parts, such as electric blankets, steam irons or similar small appliance.

Type of manufacturing

- This is probably the most influential factor in the control situation. A large, manufacturing plant producing a standard product is included in planning of the plant layout design.

1.8 Role of the Human Relations Movement in Production

- During the Great Depression of 1930’s, Elton Mayo, Roethlisberger, Whitehead, Dickson, and others carried out Hawthorne experiments in a plant of the Western Electric company.
- These studies were undertaken to study the relationship between physical environment and worker productivity. It was then realised that human factors affect productivity.
- Later on Chester Bernard, Maslow, Herzberg, Douglas Mcgregor, Peter Drucker and others emphasised the role of the workers and their attitude towards work and insisted upon maintaining motivated labour force, so that capabilities and energies of the workers can be utilised for the purpose of production.

1.9 Role of Computer and Advances in Production Technology

- Since 1954, the application of computer technology in the field of business increased rapidly. Initially computers were to carry out clerical work such as preparing payrolls, bills, inventory transaction, and cost reports and so on.
- But now computer simulation, computer-aided design and manufacturing (CAD/CAM), group technology, cellular manufacturing system, decision support systems experts systems and artificial intelligence have become quite common in use.
- Now managers are using computers to analyse complex problems and to find out solutions. Recently several Japanese management techniques such as Kanban Systems, Just-In-Time, Quality Circles, etc. have become popular and useful.
- Now cellular manufacturing systems (CMS), Flexible Manufacturing Systems (FMS) etc. are widely used in the process of production.
- The Japanese technique of lean production has attracted the attention of business world because of its focus on core competencies, flexibility, speed, integration of design and operations and the right type of people.
Summary

- Production is the core activity of the industrial organisation and all other activities revolve around this activity. It is the process of bringing together men, materials and machines for producing goods and services desired by the society to satisfy the wants of the people.
- Manufacturing or production is a process of converting raw material into finished products to satisfy the needs of the members of the society.
- The ultimate objective of production planning and control, like that of all other manufacturing controls, is to contribute to the profits of the enterprise. As with inventory management and control, this is accomplished by keeping the customers satisfied with meeting of the delivery schedules.
- Type of product and type of manufacturing are the two deciding factors in production planning and control procedure.
- Human resources and application of advanced technologies play vital role in the effective planning of production and gain maximum output. Managers are now using computers to analyse complex problems and to find out solutions which have helped in saving time as well as money. Several Japanese management techniques such as Kanban systems, just in time, quality circles, etc. have become popular due to their usefulness.

Reference


Recommended Reading

Self Assessment

1. ___________ is the core activity of the industrial organisation and all other activities revolve around this activity:
   a. Production
   b. Development
   c. Maintenance
   d. Measurement

2. ___________ specialised in certain tasks may suggest improvement in existing production methods.
   a. Employees
   b. Workmen
   c. Staff
   d. Manager

3. ___________ is the last step of planning functions.
   a. Implementation
   b. Development
   c. Scheduling
   d. Improvisation

4. ___________ is concerned with those processes which convert the inputs into outputs.
   a. Development
   b. Maintenance
   c. Measurement
   d. Production

5. Which of the following statement is false?
   a. Scheduling is the first step of planning functions.
   b. Re-planning is not a corrective action.
   c. Authorising the start of an operation on the shop floor is the function of dispatching.
   d. Workmen specialised in certain tasks may suggest improvement in existing production methods.

6. State which of the following statement is true.
   a. Customer’s orders, sales orders and stock orders are not for the finished product
   b. The plan for the processing of materials through the plant is established by the functions of process planning, loading, and scheduling
   c. Jobs authorise the performance of individual operations in the manufacturing process
   d. Scheduling is the first step of planning functions.
7. Which of the following is considered to be the second order class out of the five classes of orders?
   a. Stock order
   b. Stock exchange
   c. Sale order
   d. Shop order

8. According to whom production is concerned with those processes which convert the inputs into outputs?
   a. Brech E. L
   b. Harry MJS
   c. Buffa E.S
   d. Harding H. A

9. Which of the following is prepared to show the productive capacity that has been “sold” – and at the same time the available productive capacity?
   a. Route Sheet
   b. Load chart
   c. Process sheet
   d. Order sheet

10. Which of the following authorises the performance of individual operations in the manufacturing process?
    a. Load chart
    b. Job tickets
    c. Job control
    d. Order sheet
Chapter II
Objectives, Scope and Importance of Production Planning and Control

Aim
The aim of this chapter is to:

- explore the objectives and scope of production planning and control
- explain the importance and limitations of production planning and control
- evaluate difference between production planning and production control

Objectives
The objectives of this chapter are to:

- identify the objectives of production planning and control
- determine the scope, importance and limitations of production planning and control
- explain the process of establishing a production planning and control department

Learning outcome
At the end of this chapter, the students should be able to understand:

- objectives, scope and importance of production planning and control
- difference between production planning and production control
- importance and limitations of production planning and control
- the requisites of establishing such a department
2.1 Introduction
Before beginning any project one of the most important tasks is its planning. Production Planning and Control (PPC) consists of planning the production in a manufacturing organisation before any production activities initiates and exercising various control actions to ensure that the planned production is realized in terms of quality, quantity, cost of production and delivery schedule.

2.2 Objectives of Production Planning and Control
The main objectives are to:
- attain maximum utilization of resources
- produce quality products
- minimise manufacturing cycle time
- maintain optimum inventory levels
- achieve coordination between labour, machines, and other supporting departments
- eliminate bottle-necks at all levels of production
- achieve cost-reduction and cost control
- prepare and maintain the production schedules
- achieve the goals at minimum cost
- ensure quality management

2.3 Scope of Production Planning and Control
Production planning and control covers the following areas:
- procurement of raw materials and spare parts in right quantities with right specifications at right time from the right source at the right cost
- opting for the best method of processing and selecting the best sequence of operations
- planning for manpower with appropriate expertise and required skills
- planning the layout of various operations to be performed
- preparing and maintaining the time lines
- ensuring continuous inspection over products produced
- imposing controls over costs and to get the work done according to the schedule

On account of such a wide scope of production planning and control, it is considered as an essential part of the corporate planning process in all the modern multi-product manufacturing organisations.

2.4 Importance of Production Planning and Control
The cycle of production planning and control act as the nervous system of an organisation. A well-organised system of production planning and control enables in providing better economic goods to customers at lower cost. The importance of production planning and control is summarised below:
- It coordinates all phases of the production system.
- An efficient system results into better quality, optimum utilisation of resources, lower level of inventories, reduction in production cycle time, faster delivery of products, more efficient customer service, lower costs of production, lower capital investment, and so on.
- It results into higher sales, more profits, increase in market share, increase in competitive advantage and so forth.
- As a result of systematic planning and control, machinery breakdowns are minimised, maintenance is improved, excess capacity and idle time is minimised and a steady flow of goods is maintained.
- It is useful in keeping all the operations in an organisation systematic. Such an organisation is in a position to meet the deadlines and orders in time that satisfies its customers.
Customer satisfaction in turn leads to increased sales, profits, industrial harmony and, eventually, good public image of the organisation.

2.5 Limitations of Production Planning and Control
In spite of several benefits of production planning and control, it has certain limitations. These are as follows:

- It is based upon certain assumptions or forecasts about level of demand, availability of materials, technological progress, government policies and so on. If these assumptions go wrong the production planning and control function may turn out ineffective.
- It is costly and time-consuming exercise.
- It becomes a difficult exercise especially when external environmental factors changes rapidly.
- The employees may refuse to accept sudden alterations if planning involve several changes.

2.6 Features of Production Planning and Control
Features of production planning and control are mentioned below in detail.

2.6.1 Production Planning
It deals with planning the work. Planning involves collection of data on materials, machines, tools and equipments, drawings, layouts and so on. Planning is basically a thinking process so it involves lot of paper work, preparing necessary forms etc.. It needs feedback so as to know whether the actual performance is proceeding according to plan or not.

2.6.2 Production Control
It deals with implementing the plan and involves utilisation of data, reporting about output, efficiency of labour and machines, inventory control, quality control and so on. Control involves actual use of the forms for reporting about production activities to the higher authorities. It aims at controlling the actual operation to be executed as per the schedule. If any deviation is observed then corrective action is taken.

2.7 Comparing Production Planning and Production Control
From the following table below it may be observed that production planning and production control are not only complementary but they are even interrelated.

<table>
<thead>
<tr>
<th>Production Planning</th>
<th>Production Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>It deals with planning the work</td>
<td>It deals with implementation of plan</td>
</tr>
<tr>
<td>Planning is forward thinking</td>
<td>Control involves looking backwards and taking steps to maintain time schedule</td>
</tr>
<tr>
<td>Planning is basically centralised activity controlled by the top management</td>
<td>Control is a decentralised activity</td>
</tr>
<tr>
<td>Production planning include estimative output to be produced, routing or determine sequence of operations, scheduling and loading.</td>
<td>Production control includes the functions of dispatching expediting follow up, progressing</td>
</tr>
</tbody>
</table>

Table 2.1 Comparison between production planning and production control

2.8 Establishing a Production Planning and Control Department (PPC)
Establishing a PPC department includes decisions related to:

- current status of PPC in the company
- extent of centralisation
- appropriate internal structure
2.8.1 Status of PPC in the Company

- The status of PPC department in the company is dependent on the manufacturing processes that the company intends to perform.
- When repetitive work is involved and the number of workers is limited, planning is done directly by the line staff.
- In manufacturing units where plant and machinery are laid out as per sequence of operations, the PPC acts as a part of the manufacturing department.
- The PPC is set-up as a separate department in firms where a variety of products are produced or where machine capacities vary for different products.

2.8.2 Extent of Centralisation

The extent of centralisation means the degree of control between the top management and the autonomy provided. These can be of two types.
1. Centralised planning- it is done by specialists
2. Decentralised planning- the line staff plans the work to be carried out in their own department

Each of the above types of planning has its merits and demerits:
- In centralised planning, the line staffs are relieved from the load of planning thus allowing them freedom to effectively handle both men and machines.
- Decentralised planning allows the line staff to participate and use their experience in performing the tasks. But, it also consumes their time in planning the functions.
- The degree of centralisation needed is greater if the number of products manufactured is very large. Centralisation is necessary where large number of workmen and machines with different capacities are involved.
- In contrast, a de-centralised planning is desirable where less number of operators are involved and the end product can be produced with less complex operations. In de-centralised planning, interaction and cooperation between various deparths is possible.

2.8.3 The Appropriate Internal Structure

The functions given to the PPC department are related to:
- the nature of industry
- size of the company
- management policies of the company

Following are the common functions related to the PPC department:

![Fig 2.1 Functions of PPC Department](image_url)
Some of the additional possible functions of PPC department are:

- estimation of costs
- measurement of work
- demand forecasting
- sub-contracting
- capacity planning

The production and control department can have the various subdivisions for better functioning such as materials control, tools control, process planning, scheduling, dispatching, progressing, cost estimation, and sub-contract work measurement. Each of the unit is staffed by a senior engineer and has additional staff members for planning.
Summary

- Production planning and production control are two very important processes of any manufacturing organisation. Both the processes are complementary as well as interrelated to each other and are often considered as being one function.

- These are essential processes that ensure that manufacturing of the products in an organisation is carried out according to the planned schedule. The production planning deals with planning the work whereas production control deals with implementing the plan.

- PPC has certain limitations, merits and demerits and plays a vital role in smooth functioning of a company and increases its output, income, capacity and so on.

- Establishing a PPC department in a company includes decisions related to current status of PPC in the company, extent of centralisation and appropriate internal structure.

- The PPC department is set as a separate department in the firms for smooth functioning of the organisations. Effective PPC can contribute to the quality of products, time as well as cost parameters and thus overall success of the organisation.

Reference


Recommended Reading


Self Assessment

1. The cycle of production planning and control acts as the ____________ of an organisation.
   a. heart
   b. project
   c. nervous system
   d. theme

2. Planning needs ___________ so as to know whether the actual performance is proceeding according to plan or not.
   a. response
   b. feedback
   c. input
   d. output

3. ___________ is necessary where large number of workmen and machines with different capacities are involved.
   a. Centralisation
   b. De-centralisation
   c. Analysis
   d. Materials

4. ___________ planning allows the line staff to participate and use their experience in performing tasks.
   a. Centralised
   b. Decentralised
   c. Analytical
   d. Advanced

5. The degree of ______________ needed is greater if the number of products manufactured is very large.
   a. centralisation
   b. decentralisation
   c. analysis
   d. advancement

6. Which of the following is false?
   a. The cycle of production planning and control serves as the nervous system of an organisation.
   b. Planning needs feedback so as to know whether the actual performance is proceeding according to plan or not.
   c. The degree of centralisation needed is greater if the number of products manufactured is very small.
   d. The degree of centralisation needed is greater if the number of products manufactured is very large.

7. The functions given to the PPC department are related to which of the following?
   a. Size of the company
   b. Number of employees
   c. Rules of the company
   d. Capital
8. Which of the following deals with planning the work?
   a. Production control
   b. Production planning
   c. Production system
   d. Manufacturing system

9. Which of the following are the limitations of production control?
   a. It is based upon certain assumptions
   b. External conditions cannot be controlled
   c. It is costly and time consuming exercise
   d. It is difficult to understand

10. Which of the following is a function related to PPC department?
    a. Control of materials
    b. Control of goods
    c. Analysing
    d. Preparing reports
Chapter III
Methods of Production

Aim

The aim of this chapter is to:

- explore various methods of production
- explain intermittent and continuous production methods and their types
- enlist factors affecting selection of production process

Objectives

The objectives of this chapter are to:

- illustrate production system and classify the methods of production
- clarify merits and demerits of various production methods
- explain types of production methods

Learning outcome

At the end of this chapter, the students should be able to:

- understand production system
- identify various methods of production and their merits and demerits
- recollect the types of intermittent and continuous production methods
- recognise factors affecting selection of production process
**3.1 Introduction**

Any manufacturing organisation is based on a production system. Production is a conversion process where inputs are received from the environment. These inputs are processed so as to produce goods desired by the society. The finished goods are outputs which are sold back to the environment. The combination of activities and operations stated above employed to create goods is known as production system. The production system is depicted below:

![Production System Diagram](image)

**3.2 Classification of Production Methods**

The following figure shows methods of production system:

![Classification of Production Methods Diagram](image)

The production methods are mainly of two types:
1. Intermittent production
2. Continuous production
3.3 Intermittent Production

Under intermittent method of production the products are produced in “lots” to fulfil orders made by the customers rather than producing for the stock. The flow of material is intermittent rather than continuous. The production facilities are flexible so as to handle a large variety of products and sizes. This system can be used for manufacturing those products where the basic nature of inputs tends to change with the changes in the product design and the production process also requires frequent adjustments.

Examples of intermittent system are machine shops, general office, hospitals and so on.

Following are the advantages and disadvantages of intermittent production:

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>It enables to produce a large variety of products at low cost because of the use of general purpose machines.</td>
<td>It is relatively costly for larger volumes because of higher level of variable costs of general purpose machines.</td>
</tr>
<tr>
<td>The capacity utilisation tends to be higher.</td>
<td>As the jobs are complex, the problems of planning and control tend to increase.</td>
</tr>
<tr>
<td>Flexible to suit production variations.</td>
<td>In the process, inventory tends to be larger and stocks of work in progress also accumulate significantly.</td>
</tr>
<tr>
<td>Each worker gets an opportunity to complete the job which gives him pride and sense of responsibility.</td>
<td>Many times costly equipment may be required for material handling, which also requires larger space.</td>
</tr>
</tbody>
</table>

Table 3.1 Advantages and disadvantages of intermittent production

3.3.1 Project Production

Project production is characterised by complex activities that must be performed in a specific sequence within the given period and within the estimated cost. When the output of the project is a product such as ship, aircraft or locomotive etc the final product being huge in size, remains fixed or stationary during the process of transformation. Operations of such huge products are carried out in “fixed position assembly type of layout.”

Characteristics of project production

The project production has certain characteristics as follows:

- **Short life cycle:** Projects have a short life cycle along with definite beginning and end.

- **Non uniform requirement of resources:** The resource requirement for project production is not uniform, because there are fewer requirements of resources in the beginning but the requirements of resources builds up fast along with the progress of the project. More and more resources are absorbed, and then it levels off until there is steady cutback as the project move towards completion.

- **Fixed type of layout:** As the final product is huge in size there is immobility during the process of transformation. The operations are carried out in fixed position layout as in case of ship building or locomotives.

- **Involvement of many agencies:** A project generally involves different tasks, each having its own specialization to be performed by different agencies. The tasks generally are performed in a particular sequence (i.e. certain tasks must be completed before the next begins). Hence a proper coordination between different specialized is of utmost importance.

- **Scheduling and control:** as a large number of activities are to be performed by different special agencies in strict precedence, there is an urgency to have an effective scheduling and control. For this purpose, network planning techniques like Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM) has been observed to be more useful.
• **High cost of overruns:** Many a times a project may be delayed because of certain unexpected events taking place, such delay turns out to be very costly because of increase in the cost of production and payment of heavy penalties.

• **Matrix form of organisation:** When several projects have to be undertaken simultaneously matrix form of organisation is most suitable. The activities of the functional specialists are coordinated by the project managers.

• **Personnel problems:** Project production has many personnel related problems like:
  - when there is a fast build up, staff is either borrowed from other departments or hired for short duration therefore, personnel involved in the project have limited (or short lived) interest in the project
  - temporary manpower may start looking for alternative jobs when the project is in final state
  - as each project has limited duration some staff members may spend more time to get prepared for next project
  - projects may be located in backward regions where socioeconomic infrastructure may not be well developed hence normal life may get dislocated

3.3.2 **Job Production**

Job production is characterised by the manufacture of one or few numbers of a single product designed and manufactured strictly to customer’s specifications within, the given period and within the fixed cost prior to tile contract. It is also known as “Job Lot Manufacturing”’. The whole product is considered as one job that is to be completed before taking up another job. Some common examples of industries that are engaged in job production are general repair shops; tool manufacturers; workshops to manufacture jigs and fixtures for other units; building contractors; manufacturers of ships, cranes, turbo-generators, furnaces, pressure vessels; and others manufacturing articles made according to customers orders.

**Characteristics of job production**

The main features of the job production may be stated as follows:

• **Small production runs:** Job production is characterised by the manufacture of one or few units of a product at a time, under a separate contract. The production is made strictly to customers’ specifications.

• **Disproportionate production cycle time:** As there are frequent changes in job designs, detailed planning has to be done for every job. Usually delays occur on account of lack of materials or components, design errors, etc. which lengthens the manufacturing cycle.

• **Discontinuous flow of material and components:** The flow of materials and the components tend to be discontinuous due to frequent job alteration.

• **Plant layout:** Plant and equipment is designed and arranged to obtain maximum flexibility. General purpose machines and handling equipments are capable of performing variety of operations with minimum time and cost. Similar machines, capable of doing similar type of operations, are grouped together. The grouping of machines gives a lot of flexibility in scheduling and loading.

• **Employing highly skilled workers:** In order to carry out the job production more efficiently skilled and experienced employees are essential because there they would carry out the job with the new instructions and less supervision. As the workers are experts, they can use complicated machines and more sophisticated equipments to produce quality products.

• **The nature of supervision:** For the purpose of the job production, highly skilled supervision is obligatory. Highly competent engineers are occupied as foreman in the base workshop and a group of site engineers, practical men, with systematic training, capable of taking independent charge of each contract are employed to work at site. Therefore, these supervisors in a job production are the reservoir of job knowledge.
3.3.3 Batch Production

Batch production is characterised by the production of a limited number of products manufactured at regular intervals and retained in warehouses as finished goods. In case of batch production the product is divided into various parts or operations, called as batches, so as to complete each operation carefully. Thus, unless one batch is completed, the plant and machines are not available for the production of second batch.

Characteristics of batch production

The main features of Batch production may be stated as follows:

- **Knowledge of a specific process**: The supervisors possess considerable knowledge and are specialists in their own field. However, the need for supervisors in batch production tends to be lowered as compared to the job production.

- **Material handling**: As compared to the job production, material under batch production is small. Sometimes mechanisation of material handling systems may be used.

- **Huge work-in-progress**: Work in progress is comparatively large due to varying work content of different components, imbalances in production times, formation of queues linking the machines.

- **Plant layout and equipments**: General purpose machines and equipment are used in order to achieve flexibility. The machinery is arranged in process layout where machines carrying out similar jobs are placed together.

- **Need of production planning and control**: Functions of production planning and control in a batch production unit are more complicated as compared to job production.

3.4 Continuous Production

Continuous production is characterised by complex activities that must be performed in a specific sequence within the given period and within the estimated cost. In fact, the production is stocked, hence it is necessary to carry out sales forecasting to estimate probable demand of the products and prepare schedule to adjust the sales forecast with the level of inventory. Inputs are standardised and standard process setup is adopted. As a result of routing and scheduling, the whole process can be standardised for smooth production process.

Following are the advantages and disadvantages of continuous production:

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is possible to maintain higher accuracy</td>
<td>Continuity of demand is required</td>
</tr>
<tr>
<td>Direct labour content is reduced</td>
<td>The product must be standardised</td>
</tr>
<tr>
<td>Work in progress tends to remain at the minimum level</td>
<td>The operation stages in the process have to be balanced</td>
</tr>
<tr>
<td>Storage at different stages of operation is not necessary</td>
<td>The material should be according to specifications and must be available in time</td>
</tr>
<tr>
<td>Material handling is significantly reduced</td>
<td>Appropriate plant and equipments should be provided</td>
</tr>
<tr>
<td>Control process is very simple</td>
<td>The work should be carried out according to quality standards</td>
</tr>
<tr>
<td>Any weakness in the system can be easily located</td>
<td>Proper maintenance of machinery and equipment is necessary</td>
</tr>
<tr>
<td>Minimum level of locking up of working capital</td>
<td>Inspection must be in line with the production</td>
</tr>
</tbody>
</table>

Table 3.2 Advantages and disadvantages of continuous production
3.4.1 Mass or Flow Production
Under mass or flow production items are produced in large quantities and consumer’s orders are rarely entertained. Thus, production is mainly for stock and not as per order. Machines, methods, materials etc. are standardised and uniform and steady flow of materials is maintained through standardised sequence of operations to produce the output. This system can produce only one type of a product at one time.

Characteristics mass or flow production
- Continuous flow of materials takes place and at any stage of processing there is no queuing.
- Special purpose machines are to be used and the plant assembly is based on product layout system.
- Highly skilled workers are not desired.
- Material handling tends to be less as materials move over short distances between different stages and is mostly done mechanically.
- Manufacturing cycle time is shorter.
- Supervision is easier on account of standardisation and hence very few instructions are required.
- Breakdowns of machinery and equipments and absenteeism amongst workers affect the level of production and failure of one machine may give rise to complete stoppage of entire work system.

3.4.2 Process Production
This system of production is similar to mass production system with more emphasis on automation in production process. The volume of production is very large. Generally a single product is produced on a very large scale and stocked awaiting sales. Flexibility tends to be absent because of production of single item only. Such processes of production are common in industries like sugar, cement, steel, paper and so on.

Characteristics of process production
- The plant layout, shape and size of buildings, location of services are such that material flow is unidirectional at slow and steady rate, special purpose machinery and equipments with built in controls are used to regulate input and to measure output.
- Higher level of mechanisation in material handling is common.
- The manufacturing cycle time is near to zero because inflow of raw material at one end and the production of finished goods at the other end is such that the whole plan is like one big machine.
- Work in progress tends to be very small on account of continuous flow of materials
- High quality supervision is required.
- Semi skilled workmen and skilled technicians are desired.

3.5 Factors Affecting Selection Production Process
There are several factors which affect the selection of production process such as:
- capacity of plant
- lead time
- flexibility
- environment
- demand
- effect of volume/variety
Summary

- This chapter covered the production system and its two main types called intermittent and continuous process.
- Production is a conversion process where inputs are received from the environment. These inputs are processed so as to produce goods desired by the society. The finished goods are outputs which are sold back to the environment. The combination of activities and operations stated above employed to create goods is known as production system.
- Intermittent production process is further classified into project production, job production, batch production methods. Continuous production process is classified into mass or flow production, process production.
- In intermittent method of production, the products are produced in large quantities to fulfil orders made by the customers rather than producing for the stock.
- In continuous production the items are produced in larger quantities and emphasis is not given to consumers orders.
- The chapter also explains characteristics of each of the production process to make a right choice.
- Several factors which are considered before selecting a production process include capacity of plant, lead time, flexibility, environment, demand and effect of volume/variety.

Reference

- Methods of Production

Recommended Reading

Self Assessment

1. Production is a ____________ process where inputs are received from the environment.
   a. conversion
   b. exchange
   c. measuring
   d. alteration

2. ____________ production is characterised by complex activities that must be performed in a specific sequence within the given period and within the estimated cost.
   a. Cost
   b. Project
   c. Product
   d. Machine

3. ____________ production is characterised by the production of a limited number of products manufactured at regular intervals and retained in warehouses as finished goods.
   a. Job
   b. Mass
   c. Batch
   d. Flow

4. Under ____________ production items are produced in large quantities and consumer’s orders are rarely entertained.
   a. batch
   b. job
   c. variable
   d. mass

5. State which of the following is false.
   a. The intermittent production facilities are flexible so as to handle a large variety of products and sizes.
   b. High quality supervision is required not for process production.
   c. Under batch production general purpose machines and equipment are used in order to achieve flexibility.
   d. Unless one batch is completed, the plant and machines are not available for the production of second batch in batch processing.

6. Control process is very simple in which of the following?
   a. Continuous process
   b. Non-continuous process
   c. Variable process
   d. Fixed process

7. The capacity of utilisation tends to be higher in which of the following?
   a. Cost process
   b. Intermittent process
   c. Manual process
   d. Intern process
8. Which of the following is not the factor that affects the selection of production process?
   a. Capacity of plant
   b. Lead time
   c. Flexibility
   d. Effectiveness

9. Which of the following is not a type of continuous production process?
   a. Mass production
   b. Flow production
   c. Process production
   d. Material production

10. Which of the following is not a type of intermittent production process?
    a. Flow production
    b. Project production
    c. Job production
    d. Batch production
Chapter IV
Plant Layout

Aim
The aim of this chapter is to:

• explain the principles of plant layout design
• evaluate factors affecting plant layout
• elucidate various types of layouts and their merits and demerits

Objectives
The objectives of this chapter are to:

• study the principles of plant layout design and its objectives
• enlist internal and external factors affecting plant layout
• identify types of plant layout and their features

Learning outcome
At the end of the chapter, the students should be able to:

• identify principles and objectives of plant layout design
• understand internal and external factors affecting the design
• recollect the types of plant layout and their features
4.1 Introduction

Plant layout refers to the planning or arrangement of various physical components such as machines, equipment, tools, furniture and so on, in a particular manner so as to have quick flow of material at the least expenditure and with the lowest amount of handling in processing the product from the reception of raw material to the delivery of the finished product.

A good layout is one which allows flow of materials rapidly and directly for processing. This reduces down the cost of transport, handling, clerical and others space requirements are reduced and it decreases idle machine and idle man time. Plant layout is an effort to arrange machines and equipments and other services within a pre-designed space ensuring steady, smooth, and economical flow of materials.

4.1.1 Objectives of Plant Layout

A well planned and designed plant layout is one that can be useful in achieving the following objectives:

- efficient and proper utilisation of available floor space
- effective utilisation of production capacity
- reduction in material handling costs
- utilisation of labour force efficiently
- provide for volume and product flexibility
- provide easiness of control and supervision
- provide employee safety
- allow easy maintenance of plant and machines
- improve productivity
- reduce accidents

4.2 Principles of Plant Layout

Following are the principles of an ideal plant layout:

- **Integration of various factors:** integrate men, materials, machines and supporting services in such a way that it leads to the optimum use of all the factors of production.
- **Unidirectional flow:** materials should flow is in one direction (forward – only) towards the final state of completion.
- **Minimum movement:** according to the principal of minimum movement, should prefer minimum movement between various operations.
- **Minimum handling:** reduce the activities relating to the material handling to a minimum.
- **Maximum accessibility:** provide for making servicing and maintenance points easily accessible.
- **Optimum use of available space:** aim at making optimum and productive use of the available space.
- **Safety measures:** make the plant safer for the workers.
- **Good working environment:** provide healthy work environment.
- **Flexibility:** can be adjusted easily and without huge costs to suit changing conditions.
- **Inherent safety, maximum security and visible routes:** provide safety to employees working there and also protect the plant from fire, theft and general deterioration.
4.3 **Advantages of Plant Layout**

There are several advantages of a good layout which may be studied from different points of view as follows:

**Advantages to the workers**
- creates better working conditions
- reduces number of accidents
- helps to work with maximum efficiency
- provides scope for specialisation
- reduces the number of handlings
- helps in reducing the efforts of workers

**Advantages of supervision**
- makes supervision simple and easier
- helps in reducing number of inspections
- reduces the cost of supervision

**Advantages regarding reducing costs**
- enables the management to reduce the number of workers and hence the cost of labour
- tends to increase the production per person per hour
- helps in reducing the length of haul
- reduces unproductive motions between operations
- decreases the costs of maintenance and replacements
- minimises spoilage and scrap
- reduces wastages of raw materials
- improves the quality of output due to reduction in number of handlings
- helps to achieve economy in power consumption
- enables effective control

**Promotion of the efficiency of production control**
- enables to provide adequate and convenient storage facilities
- helps in providing better facilities for receipts, shipment and so on
- increases speed and efficiency of production
- enables to maintain time schedule of production

**Advantages relating to investments**
- helps in reducing investment in machinery and equipment due to increase in output, utilisation of idle machine time, reducing number of operations, and so forth
- helps in maintaining proper balance between different departments related to production
- reduces total permanent investment
- reduces investment in material handling equipments, work in progress and maintaining stock of finished goods
4.4 Factors Affecting Plant Layout

Factors affecting plant layout can be classified as external and internal factors. These are explained below in detail.

**External factors**
- availability of transportation facilities
- receiving operations such as unloading, stores and so on
- storage facilities
- dispatching operations (shipping)
- packaging operations
- office and other support facilities
- diverse climatic conditions

**Internal factors**
- **Nature of product and process**: Heavy products need stationary layout, while line layout is suitable for production of light products which can be moved easily from one machine to another. The process layout is suitable when part and product design are not stable.
- **Volume of production**: Quantity of production and the standardisation of the product also affect the type of layout. If standardised commodities are to be manufactured on a large scale, line type of layout is adopted.
- **Nature of plant location**: The size, shape and topography of the site where the plant is located also affect the layout. For example, if a site is near the railway line, the arrangement of general layout for receiving and shipping and for the efficient flow of production in and out the plant may be made by the side of the railway lines. If space is narrow and the production process is long, the layout of plant may be arranged on the land surface.
- **Management policies and decisions**: Management policies regarding size of the plant, kind and quality of the product, scope for expansion, etc. also affect location of a plant.
- **Type of process**: it is an intermittent process of production calls for functional or process layout, while continuous process of production needs line type of layout.
- **Nature of machinery and equipment**: The nature of nature of machines and equipment also affects the plant layout. If machines are heavy in weight or create noise, stationery layout is preferred. Heavy machines are generally fixed on the ground floor.
- **Nature of raw materials**: Design and specification of raw materials, like physical properties, quantity and quality of raw materials, etc. affect the plant layout.
- **Human factors and working conditions**: Men are the most important factor of any production system and therefore special consideration for their safety and comforts should be provided while planning a layout, specific safety items like obstruction-free floor, workers non-exposure to hazards, exit etc. should be supplied.
- **Characteristics of the building**: Shape of building, covered and open area, number of storeys, facilities of elevators, parking area and many other similar factors influence the layout plan.

4.5 Types of Layout

A layout refers to the arrangement and grouping of machines and equipments so as to produce the products efficiently and economically. It calls for grouping of machines and other production facilities which can be done in different ways as follows:
- process, functional or job shop layout
- product, line processing or flow line layout
- fixed position or static layout
- Cellular Manufacturing (CM) or group technology layout
- combination or hybrid layout
4.5.1 Process Layout
It is also called as functional layout. All machines performing similar kind of operations are grouped together at one location in the process layout, for example, all lathes, milling machines, grinding machines, cutting machines etc. are clustered together. Thus all forging will be done in one area and all the lathes will be placed in another area. This type of process is more suitable to job and batch of production. In such production the operation differs from product to product. So, it is desirable to arrange the machines on the basis of process rather than on the products. Following are the advantages and disadvantages of process layout:

**Advantages**
- low initial investment
- maximum utilisation of available resources
- breakdown of one machine does not stop the production process
- higher rate of output
- greater flexibility of resources
- better working conditions
- overhead costs are low

**Disadvantages**
- longer processing time
- needs substantial planning and control
- needs highly skilled workers
- material handling costs is high
- time-consuming process

4.5.2 Product or Line Processing Layout
In this type of layout the machines and equipments are arranged in one line depending upon the sequence of operations required for the product. It is also called as line layout. The material moves to another machine sequentially without any backtracking or deviation, i.e. the output of one machine becomes input of the next machine. It requires a very little material handling.

![Fig. 4.1 Product or Line Processing Layout](image)

Following are the advantages and disadvantages of product layout

**Advantages**
- smooth flow of production
- manufacturing time is saved
- reduced materials handling costs
- lesser work in progress and lesser inventory
- optimum use of available space
- effective production control
- efficient supervision
- lower cost of labour procurement and training

**Disadvantages**
• inflexibility as the operation are carried out in sequence, hence change in the process cannot be achieved easily
• work can stop through breakdown
• need of high capital investment
• higher labour cost
• production cost is volume dependent

4.5.3 Fixed or Stationary Layout
In fixed or stationary position layout, the movement of manpower and machines to the product remains stationary. The movement of men and machines is advisable as the cost of moving them would be lesser. This type of layout is ideal where the size of the job is heavy and large. For example, locomotives, ships, wagon building, aircraft manufacturing, and so on.
Following are the advantages and disadvantages of fixed layout

Advantages
• simple and highly flexible layout
• workers can be fully employed
• time-saving
• optimum utilisation of floor space

Disadvantages
• heavy equipments are used
• due to the low efficiency of men and machines it is used for special cases only
• higher investment is needed

4.5.4 Cellular Manufacturing Layout
Under cellular manufacturing layout, machines are placed within the cells that function on the lines of product layout within a larger shop or process layout.

Fig. 4.2 Cellular manufacturing layout

Each cell in this layout is formed to produce a particular part of the product. Few parts have common features and require same machines and have similar machine settings. The movement of the parts in different cells may take different forms. In cell 1 and 2, the parts flow through the same machines in line flow pattern. But in cells 3 & 4, parts take different routes through the cells on account of differences in designs of both the parts.

Following are the advantages and disadvantages of fixed layout

Advantages
• work in progress inventory tends to be lower
• material handling costs are also lower
• shorter flow times in production
• production planning is simple and easier
• responsibilities on the operators increases
• improved visual control
• less tooling changes and quicker setups
• significant reduction in costs of production
• delivery schedule can be maintained
• improvement in quality takes place

Disadvantages
• flexibility is reduced
• machine's down time also increases
• machines are placed in the cells and used all the time
• duplicate machinery and equipment may be required as these have to be located in cells permanently

4.5.5 Combined or Hybrid Layout
In practice, a pure process or a pure line layout is rarely found. Both are considered to be mutually exclusive. However, if a proper combination of both these types of layouts is achieved, then it is possible to gain the advantages of both. This is done in combined or hybrid layouts. This is an arrangement in which some portions of the facility have a flexible-flow and others have a line-flow layout.
Summary

- The chapter describes the various aspects of a good plant layout. It discusses the various types of layouts giving their merits and demerits.
- A layout is the physical configuration of work stations and equipments, in the conversion process. It is a special arrangement of physical resources that are used to manufacture the product. The arrangement of the various parts of a plant along with all the equipment used is known as plant layout.
- Having a proper layout of the plant and machinery is a key step in manufacturing management. Thus, it may be concluded that an ideal layout helps not only in achieving the objectives of business but also provides motivation and job satisfaction to the workers.
- There are several factors like storage facilities, nature of raw materials, types of process etc. that affects the plant layout. They need to be taken into consideration while taking decisions about the layout. They not only affect quality and quantity of production but also the cost of production.
- There are five types of plant layout viz. Process layout, product or line processing or flow line layout, fixed position or static layout, Cellular Manufacturing (CM) or group technology layout and combination or hybrid layout. Each type has its own merits and demerits. Which type of layout is to be chosen depends on the type of manufacturing products. Generally for heavy and bulky products fixed type of layout is adopted whereas to produce small quantities but variety of products process layout is preferred.

References


Recommended Reading

**Self Assessment**

1. A good layout is one, which allows flow of materials rapidly and directly for
   ____________.
   a. processing  
   b. operation  
   c. output  
   d. feedback

2. In an ideal layout, materials flow in __________ direction towards the final state of completion.
   a. backward  
   b. forward  
   c. right  
   d. left

3. An ideal layout provides for making servicing and maintenance points easily __________.
   a. operable  
   b. accessible  
   c. handy  
   d. reachable

4. Match the following:

   | 1. Process layout | A. Less tooling changes and quicker setups |
   | 2. Line processing layout | B. The layout is simple and highly flexible |
   | 3. Fixed or stationary layout | C. Lower cost of labour procurement and training |
   | 4. Cellular manufacturing layout | D. Breakdown of one machine does not stop the production process |

   a. 1-B, 2-C, 3-D, 4-A  
   b. 1-D, 2-C, 3-B, 4-A  
   c. 1-C, 2-D, 3-A, 4-B  
   d. 1-A, 2-C, 3-B, 4-D

5. State which of the following is false.
   a. The size, shape and topography of the site where the plant is located do not affect the layout.
   b. The size, shape and topography of the site where the plant is located also affect the layout.
   c. In fixed or stationary position layout the movement of manpower and machines to the product remains stationary.
   d. Process layout is also called as functional layout.
6. Which of the following external factors do not affect plant layout?
   a. Availability of transportation facilities
   b. Receiving operations such as unloading, stores and so on
   c. Storage facilities
   d. Volume of production

7. Which of the following internal factors affects plant layout?
   a. Packaging operations
   b. Nature of raw materials
   c. Office and other support facilities
   d. Various climatic conditions

8. Which of the following is an advantage of process layout?
   a. Breakdown of one machine does not stop the production process
   b. Smooth flow of production
   c. Manufacturing time is saved
   d. Reduced materials handling costs

9. Which of the following is an advantage of fixed layout?
   a. The layout is simple and highly flexible
   b. Improved visual control
   c. Less tooling changes and quicker setups
   d. Significant reduction in costs of production

10. Which of the following is the disadvantage of product layout?
    a. Flexibility is reduced
    b. Machines’ down time also increases
    c. Machines are placed in the cells and used all the time
    d. Work can stop through breakdown
Chapter V
Material Requirements Planning

Aim

The aim of this chapter is to:

• explain the concept of Material Requirements Planning (MRP)
• elucidate objectives and advantages of MRP
• clarify the limitations of MRP and analyse its system components

Objectives

The objectives of this chapter are to:

• define MRP and determine its system components
• recognise the objectives, advantages and limitations of MRP
• know the concept of demand dependency
• understand how to update MRP in changing environment

Learning outcome

At the end of this chapter, the students should be able to understand:

• the definition of MRP and its objectives, advantages and limitations
• system components of MRP
• the concept of demand dependency
• ways to update MRP in changing environment
5.1 Introduction
In the recent times, Material Requirements Planning (MRP) systems have replaced conventional planning systems which were reactive inventory systems in several organisations. The traditional reactive systems were simple to manage but were having serious drawbacks such as high inventory costs and unreliable delivery performance. However, the new system is more complex to manage but has several advantages. It reduces inventories and their associated costs as it carries only those items and components that are actually needed. Through its forward planning approach, it ensures that all the materials required are available whenever needed for production and aims at reducing order-processing delays. By setting realistic job completion dates, jobs can be completed on time, order promises are kept and production lead times are significantly reduced. Improved customer services, along with other advantages are achieved in more ways making it economical and effective.

5.2 Definition of MRP
- Material requirements planning is a time phased priority-planning technique that calculates material requirements and schedules supply to meet demand across all products and parts in one or more plants.
- It is a computer based system in which the given Master Production Schedule (MPS) is divided into the required raw materials, parts and subassemblies needed to produce the end product in each time period, which may be a week or month of the production horizon.
- MRP is an inventory control process carried out with the aid of the computer to determine time-phased requirement of components that are used for manufacturing products on the assembly line principles.
- MRP aims at solving problems at inventory control such as, the supply of the components in right quantity at the right time, to avoid stock pilling of heavy inventory and stock deficiencies; MRP is used for dependent demand solutions. Computer architecture for MRP can be shown as follows:

5.3 System Components
Material requirements planning system can be represented diagrammatically as follows:
Under the MRP system, three major sources of information are necessary, a Master Production Schedule (MPS), a bill of materials file and an inventory status file. These components are discussed below.

**Master Production Schedule (MPS)**
- A master production schedule (MPS) is a plan for production, staffing, inventory, and so on. MPS is developed as the customer orders are received by the firm or from the forecasts of demand before the MRP system begins to operate.
- The MPS is an input to the MRP system. It is designed to meet market demand by identifying the quantity of each end product and when it is to be produced during each future period, during production planning horizon.
- Orders are placed for replacement components for customers and entered as end items in the MPS. Thus, MPS provide the important information for the MRP system.

**Bills of materials**
- A bill of materials or BOM is a list of the raw materials, sub-assemblies, intermediate assemblies, components, sub-components, parts and the quantities of each needed to manufacture the end product. This information is obtained from product design documents, work flow analysis and other standard manufacturing and industrial engineering documents.
- The MRP receives primary information from the BOM i.e. the product structure which shows various components of the product. Each item in the product is given a unique identification number. Taking into consideration the master schedule for the end items, MRP schedules the time phase for the orders for the correct components items in the production structure.

**Inventory status file**
- The MRP system must retain an updated file of the inventory status of each item in the product structure. This file provides accurate and up-to-date information about the availability of every controlled item by the MRP system, which can then maintain an accurate accounting of all inventory transactions both actual and planned.
- The inventory status file contains the identification numbers, quantity on hand; safety stock level, quantity allocated and procurement lead time of every item.
5.4 Demand Dependency

- The concept of demand dependency is important between the reactive and proactive (planning) systems. The demand dependency is the degree to which the demand for the same product is associated with the demand for another item.

- In case of “independent demand”, the demand is unrelated to the demand for other items. However, in case of a “dependent demand” situation, if we know the demand for one item, we can deduce the demand for the other related items. For example – If the demand for a product is known, we can calculate how many of its subcomponents are needed as its demand is already known.

- In the past, industries used reactive control systems such as order quantity, reorder point system ignoring the dependent and independent demand. Now, large safety stocks are not needed for dependent demand items because it is possible to calculate the exact amounts required. It is also not necessary to stock up items that are related to the dependent demand.

- According to A. K. Dutta, “the order point techniques based on Economic order quantity (EOQ) are more suited for items having independent demands because they use past usage of sales data to forecast future demands. But for items which have dependent demands such as lower level components, sub-assemblies, etc., usage data is unrelated to the past demands.

- Rather than planning for their requirements and timely availability, master production schedules, bills of materials and inventory records act as starting points. The master production schedule shows the number of finished goods and the major subassemblies.

- The bills of material prepared for each item define the precise requirements for materials and components. By consumption, total requirements are arrived at on a need time basis.

- Depending on the nature of the industry, the production process and the item, demand for an inventory item may be either discrete or continuous. Thus, variability of demand and the complexity of production process are the determining in using an order point system or time phased materials planning system.

- In job lot or batch production demand discontinuity is pronounced. When production is discontinuous, a product is broken down in many components, parts subassemblies and the materials planning system coordinates the ordering, delivery schedule and the start off time variation, which automatically minimises the time of inventory.

- As there is emphasis on timing rather than quantity, it reduces the probability of production stoppages arising out of stock outs. At the same time, it eliminates the need for maintaining large stocks, which reduces the carrying cost of inventory further.

- In practice, discontinuous demand indicates necessity and importance of proper timing of delivery schedules rather than control of inventory through quantity. The EOQ formula, which assumes constant demands subject to certain random fluctuations at times, further, assumes need for the inventory at hand at all the time. The need to replenish arises when inventory levels fall below the desirable level through constant depletion.

- It also assumes that this constant demand is predetermined. But the material planning logic assumes that material is required only when they are actually manufacturing operations and that these would be available in time.

- Earlier it was not done because of huge data processing costs and the time taken for computation. Now, with the availability of computer facilities at a cheaper rate, computation costs are declining and inventory costs are rising. Hence, it has become easier to justify time phased materials planning systems which ensure tight operational control. It is rapid, flexible and responsive to changes in the requirements.

5.5 Objectives of MRP

Following are the objectives of MRP:

- **Inventory reduction**: MRP determines the number of components needed and the time when they are needed to meet the master schedule. It enables the managers to procure the component as it is needed thus avoiding costs of excessive inventory.
Reduction in production and delivery lead time: MRP identifies quantities, timings, availabilities, procurement and production action required of materials and components to meet delivery dead lines. By coordinating inventories, procurement and production decisions MRP helps in avoiding delays in production. It helps in arranging production activities in priorities by putting due dates on consumer job orders.

Realistic commitments: Realistic delivery promises can enhance customer satisfaction and make him delighted. By using MRP, production system can give information in time and likely delivery time to prospective customers. The potential customer orders can be added to the system to show the manager how the revised total loading can be handled with the existing capacity. This will result in more realistic delivery dates.

Increase in efficiency: MRP provides close coordination amongst various work centres as production progresses through them. Hence production can be processed with fewer indirect personnel and fewer material interruptions. The information provided encourages production efficiencies.

It reduces inventory cost by reducing inventory levels.

It improves plant operating efficiency by making better use of productivity resources

Thus, the MRP technique is used as:
- requirement calculator
- manufacturing and planning control system
- manufacturing resource planning system

5.6 Advantages of MRP

MRP is not only a method of calculating how much material to order and when, but it is also a new technique of conducting manufacturing operations effectively under dynamic conditions. The main advantages of MRP are as follows:

- Reduced levels of inventory: Helps in achieving better coordination among various orders for components and production plans for parent items. As a result average inventory level tends to get reduced for dependent demand items like raw materials and work in progress.

- Better utilisation of human and non human resources: Provides accurate prior information; it helps in improving delivery systems, flow of work, avoiding intermittent delays and reducing manufacturing cycle times in jobs. All these result in optimum utilisation of all available resources.

- Improved consumer service: Enables managers to fix delivery dates that are definitely achievable. It helps in improving the company’s ability to react to changes in customer orders, improve service by providing quality products at fair prices, meet assembly dates and reduce delivery time significantly.

- Efficient financial planning: Enables to plan effective cash flow requirements. It enables to identify bottleneck work centres or capacity constraints thus helping the operations manager to take better investment decisions

- Better scheduling: provides better knowledge about priorities hence better scheduling can be undertaken easily.

- Improved vendor relations: Enables the purchase department to know the priorities and changes in due dates for orders so that purchaser places the orders on vendors accordingly. This helps in improving vendor relations.

- Efficient planning: May suggest necessary changes in the Master Product Schedule (MPS) for evaluating an alternative to it. It helps in projecting facility and equipment requirement, manpower planning etc. so that the organisation can survive and grow under competitive conditions.

- Promoting engineering efficiency: Helps in planning the time of design releases as well as design modifications.

- Dynamic nature: MRP is a dynamic system which is an important advantage. It reacts effectively with changing conditions. In fact it thrives on change. Changing conditions from the master schedule for several periods in future can affect not only the end item but also thousands of components. As the product system is computerised the management can make a new MRP computer run to revise production and procurement plans that react quickly to changes in customer demands as reflected in the master schedule.
• **Rational material decisions:** In order to maintain planned production schedules, planned order releases for necessary items have to be acted upon immediately. Thus, it enables the manager to take rational decisions.

### 5.7 Limitations of MRP

- The limitations of MRP arise from the conditions that need to be met before it can be used. Thus, for implementing MRP, computers are necessary, the product structure has to be assembly oriented, bills of material and inventory status information need to be regularly collected and computerised and a valid master schedule must be prepared.

- Limitations related to data integrity. Unreliable inventory and transaction data from the shop can ruin a well-planned MRP system. Training personnel to keep accurate is not an easy task, but it is critical for the success of MRP implementation. In general, the system must be accurate and directly useful or else it becomes an expensive ornament that is bypassed in favour of ad hoc methods.

- Top management support and proper organisation of functions such as production planning and control, materials, production, quantity, engineering and so on. Timeliness of generating information, effective communication systems, proper motivation of people, efficient leadership are necessary things for the successful implementation of MRP. Most of these can be lacking in many organisations.

### 5.8 Evaluation of MRP

The main advantages of the MRP system over conventional inventory planning approach and fixed order system are:

- improved customer services
- reduced inventory levels
- improved operating efficiency of the production departments

The MRP cannot be applied to all production systems. Conventionally, MRP is applied to production units producing discrete products for which a bill of materials can be generated. It cannot be applied to service systems like petroleum refineries or refilling systems, transportation companies and other non manufacturing systems.

MRP is more useful in process-focussed systems that have long process times and complex multistage production steps. However, MRP is not a panacea to solve all types of inventory planning problems. It cannot function effectively when there is an ineffective inventory status, BOM files are inaccurate and the MPS is unreliable. MRP can be efficiently applied where production systems are not well managed and when a comprehensive production and planning system is needed.

### 5.9 Keeping MRP Current in a Changing Environment

MRP is dynamic; it is responsive to new job orders from customers, current shop conditions and changes anticipated in the future. So, the MRP system must be updated with current information. It must provide stability for production operations in the face changing conditions. The four aspects of MRP are vital elements under dynamic environments. These are as follows:

- **Pegging:** It is a process of tracing through the MRP records and levels in the product structure to identify how changes in the records of the component will affect the records of other components. The pegging procedure shows exactly which item plans must changed.

- **Cycle counting:** An accurate record is necessary for MRP, otherwise the production schedule cannot be maintained, deliveries will be missed and labour and equipment will be inefficiently used. Cycle counting ensures that on-hand inventories correspond to the quantities shown in the MRP records. The updated records indicate the excesses or shortage of components and hence production schedules at various work centres need adjustment.

- **Updating:** When new jobs arrive or other shop transactions take place, the MRP system must be updated.
• **Time fence**: MRP has to function under dynamic environments; hence, the changes may lead to unstable and erratic shop operations or “system nervousness”. Stability can be gained by using time fences in the MRP system. The time fence is incorporated into the MPS and the shortest lead-time from raw materials to finished goods is determined. Within this time fence, the MPS is fixed.

5.10 **Manufacturing Resource Planning (MRP II)**

- Manufacturing Resource Planning (MRP II) evolved from early material requirements planning (MRP) systems by including the integration of additional data, such as employee and financial needs.
- This system is designed to centralise, integrate and process information for effective decision making in scheduling, design engineering, inventory management and cost control in manufacturing.
- MRP II is a computer-based system that can create detail production schedules using real-time data to coordinate the arrival of component materials with machine and labour availability. MRP II is used widely by itself, but also as a module of more extensive enterprise resource planning (ERP) systems.

5.11 **JIT**

- Just in Time (JIT) production is a manufacturing philosophy which eliminates waste associated with time, labour, and storage space. Basics of the concept are that the company produces only what is needed, when it is needed and in the quantity that is needed.
- The company produces only what the customer requests, to actual orders, not to forecast. JIT can also be defined as producing the necessary units, with the required quality, in the necessary quantities, at the last safe moment. It means that company can manage with their own resources and allocate them very easily.

**Benefits of JIT**

- Reduced set up times in store: A company, in this case, can focus on other processes that might need improvement.
- Improved flows of goods in/through/out warehouse: Employees will be able to process goods faster.
- Employees who possess multi-skills are utilised more efficiently: The company can use workers in situations when they are needed, when there is a shortage of workers and a high demand for a particular product.
- Better consistency of scheduling and consistency of employee work hours: If there is no demand for a product at the time, workers don’t have to be working. This can save the company money by not having to pay workers for a job not completed or could have them focus on other jobs around the warehouse that would not necessarily be done on a normal day.
- Supplies continue around the clock keeping workers productive and businesses focused on turnover. Employees will work hard to meet the company goals.

To achieve the aims of JIT a disciplined approach is needed which incorporates three principles applied to the organization:

1. Elimination of waste
2. Total Quality Management (TQM)
3. Total Employee Involvement

5.12 **KANBAN**

- Japanese are good at manufacturing products. Just ask any global producers of automobiles, copiers, or personal electronics what happened in the 1980s. They will probably tell you how the Japanese captured a large share of the global-market by creating world-class standards in design, materials, and management.
- What is often overlooked is the attempt to understand how the Japanese industry succeeds at the services that support the manufacturing process within the production field, the Kanban process is the most significant of these services.
• The concept of time-based management is nothing new for managers outside of Japan and has been in practice for many years. However, the Kanban process involves more than just in time deliveries and inventory control. Kanban process components are the most ‘exportable’ of Japanese techniques, but the complete process itself has not yet been successfully adopted outside Japan.

• The Japanese refer to Kanban as a simple parts movement system that depends on cards and boxes/containers to take parts from one work station to another on a production line.

• Kanban stands for Kan- card, Ban- signal. The essence of the Kanban concept is that a supplier or the warehouse should only deliver components to the production line as and when they are needed, so that there is no storage in the production area.

• Within this system, workstations located along production lines only produce/deliver desired components when they receive a card and an empty container, indicating that more parts will be needed in production.

• Kanban limits the amount of inventory in the process by acting as an authorization to produce more inventories. Since Kanban is a chain process in which orders flow from one process to another, the production or delivery of components is pulled to the production line, in contrast to the traditional forecast oriented method where parts are pushed to the line.

The advantages of the Kanban process are as follows:
• simple and understandable process
• provides quick and precise information
• low costs associated with the transfer of information
• provides quick response to changes
• limitation over or limits over-capacity in processes
• avoids overproduction
• minimises waste
• control can be maintained
• delegates responsibility to line workers
Summary

- In the recent times MRP systems have replaced conventional planning systems which were reactive inventory systems in several organisations offering several advantages over the conventional planning systems.
- Material Requirements Planning (MRP) is a material planning methodology which makes use of computer technology.
- Under the MRP system there are three major sources of information are necessary, a Master Production Schedule (MPS), an inventory status file and a bill of materials file.
- A master production schedule (MPS) is a plan for production, staffing, inventory, etc.
- A bill of materials or BOM is a list of the raw materials, sub-assemblies, intermediate assemblies, components, sub-components, parts and the quantities of each needed to manufacture an end product.
- The inventory status file provides accurate and up-to-date information about the availability of every controlled item by the MRP system, which can then maintain an accurate accounting of all inventory transactions both actual and planned.
- The key features of MRP are the creation of material requirements via exploding the bills of material and time-phasing of requirements using posted average lead times.
- Main objectives of MRP are inventory reduction, realistic commitments, and increase in efficiency and reduction in production and delivery lead time.
- The main advantages of the MRP system over conventional inventory planning approach and fixed order system are improved customer services, reduced inventory levels, and improved operating efficiency of the production departments.
- MRP cannot be applied to service systems like petroleum refineries or refilling systems, transportation companies and other non manufacturing systems.
- JIT is producing the necessary units, with the required quality, in the necessary quantities, at the last safe moment. It means that company can manage with their own resources and allocate them very easily.
- The Japanese refer to Kanban as a simple parts movement system that depends on cards and boxes/containers to take parts from one work station to another on a production line. Kanban stands for Kan-card, Ban-signal.

Reference


Recommended Reading

Self Assessment

1. MRP is an __________ control process carried out with the aid of the computer.
   a. inventory
   b. data
   c. production
   d. automated

2. The concept of demand dependency is important between the ___________ and proactive (planning) systems.
   a. informative
   b. reactive
   c. automatic
   d. productive

3. _____ determines the number of components needed and the time when they are needed to meet the master schedule.
   a. MPR
   b. ERP
   c. MRP
   d. PRM

4. By using MRP, ________ system can give information in time and likely delivery time to the prospective customers.
   a. development
   b. manufacturing
   c. managerial
   d. production

5. The MRP system must retain an updated file of the __________ status of each item in the product structure:
   a. inventory
   b. record
   c. index
   d. data

6. State which of the following is false.
   a. MRP is used for dependent demand solutions.
   b. MRP cannot be used for dependent demand solutions.
   c. The MPS is an input to the MRP system.
   d. The inventory status file contains the identification numbers, quantity on hand; safety stock level, quantity allocated and procurement lead time of every item.

7. State which of the following is true.
   a. The MRP receives primary information from the bills of materials.
   b. The MRP receives primary information from the inventory files.
   c. The MRP receives primary information from the managers.
   d. The MRP receives primary information from the workers.
8. Which of the following is not an objective of MRP?
   a. Realistic commitments
   b. Increase in efficiency
   c. Inventory reduction
   d. Conceptualisation

9. Which of the following is the advantage of MRP?
   a. Reduced levels of inventory
   b. Increased levels of inventory
   c. Static nature
   d. Increased lead time

10. Which of the following contains the identification numbers, quantity on hand; safety stock level, quantity allocated and procurement lead time of every item?
    a. Inventory status file
    b. Database file
    c. Register file
    d. Index file
Chapter VI
The Production Order

Aim
The aim of this chapter is to:

• explain the concept of production order
• explore types, objectives and functions of production order
• determine major tools used in preparing the production order
• elucidate master scheduling and its functions

Objectives
The objectives of this chapter are to:

• define production order and its objectives
• classify process analysis charts
• enlist guidelines for preparing work orders
• understand master scheduling and its functions

Learning outcome
At the end of this chapter, the student should understand:

• the concept of production order
• tools and charts used for production order
• guidelines for preparing work orders
• concept of master scheduling and its role
6.1 Introduction

The sequence of operations which involves men, materials and machines has to be properly analysed in a systematic manner, so that productive planning can be successful. The systematic arrangement of the organization is known as production order.

Through the production order various production control measures can be applied effectively and efficiently. It provides necessary guidelines for taking decisions about economic and efficient location and layout of plant and equipment.

The production order is also known as the graphical representation of various activities performed by men, machines and materials of a manufacturing system. It provides an essential base for formulating and implementing detailed and efficient production strategy.

6.2 Objectives and Functions of the Production Order

The main objectives and functions of production order are as stated below:

- to provide the necessary information about production design and other specifications; desired output; time by which product is to be produced; duration of various activities or operations and their sequence.
- to provide the basis for evaluating the performance of various components of production process in terms of quality, time and cost.
- to help in the operation of production control

The production planning and control provides a connection between the manufacturing unit and the sales unit of the company. An order from the customer department or from the sales department is communicated with the production planning and control department. Then the parts required for assembling the product are prepared in the order.

For goods that are already manufactured a shipment order is sent. This ensures correct delivery and maintenance of adequate stocks. The production order is then converted to a work order so as to start finalise the production activity.

In a job-order production unit, customer orders are directly converted into job orders. This is classically seen in fabrication units and units dealing with ancillaries.

The work order is numbered serially (usually a ten digit number) and there after it is identified by this number. It is sequenced to give adequate details about the work. For example, consider the identification number – 1342-11-09-0, here, 1342 indicates the job, 11 indicate the date, 09 indicate the month and 07 indicate the year in which the job was proposed.

In batch and mass production units, batch numbers are prepared for the respective work orders. Goods produced in batches or in mass production are used to create stocks for the sales program of the firm.

An inventory of the finished goods is essential to be maintained to ensure smooth functioning. A bin or stock card helps in this regard. In continuous production units where only one product is manufactured no work orders needs to be prepared.

6.3 Guidelines for Preparing Work Orders

- Sales orders shall be maintained in a register with the PPC department.
- A work order shall be raised against each sales order.
- For a sales order containing more than one item, a separate work order will be prepared for each item.
- If an order is for an assembly of a large number of items, it is included in one work order.
- For more than one sales order for the same item, separate work orders will be prepared for each sales order.
- In addition to the work orders, subsidiary orders may be needed such as shop orders or production orders.
6.4 Tools of Production Order

The important tools of production order consist of various charts which are considered as a useful means for explaining the requirements, priorities, methods, etc. of the production order. The charts used frequently for production order are:

- process analysis charts
- charts for analysis of equipment utilisation
- master schedule

6.4.1 Process Analysis Charts

- A process chart is a graphical presentation of information and events taking place during a series of operation or actions that take place in the process of manufacturing the products. Process charts represent various steps involved in such a way that anyone can clearly understand all the steps involved.

- The process charts are useful in process analysis and also for detecting the inefficiencies of the current process. The process chart activities are classified as operation, inspection, transport, delay and storage. Various symbols used to identify each activity are as given below:

<table>
<thead>
<tr>
<th>Symbols</th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>○</td>
<td>Operation</td>
</tr>
<tr>
<td>○</td>
<td>Main steps in a process, method or procedure</td>
</tr>
<tr>
<td>□</td>
<td>Inspection</td>
</tr>
<tr>
<td>□</td>
<td>Inspection for quality and check for quality</td>
</tr>
<tr>
<td>△</td>
<td>Transport</td>
</tr>
<tr>
<td>△</td>
<td>Movement of workers, materials or equipment from one place to another.</td>
</tr>
<tr>
<td>⌀</td>
<td>Delay</td>
</tr>
<tr>
<td>⌀</td>
<td>Delay in the sequence of events</td>
</tr>
<tr>
<td>▼</td>
<td>Storage</td>
</tr>
<tr>
<td>▼</td>
<td>Controlled storage</td>
</tr>
</tbody>
</table>

Table 6.1 Symbols used in process analysis

The process charts are classified into the following four types:

1. **Operation process charts**: It gives an overall view of the whole process by recording the sequence of the main operation and inspections. Hence it uses operation and inspection symbols only. The chart does not indicate where the activity takes place and who performs it, etc.

2. **Flow process charts**: Flow process chart is graphic representation of the sequence of all the operations, transportation, inspection delays, storing and so on, which may occur during a process. It also includes certain information that is essential for analysis, for example, time required and distance travelled.

The flow process charts are of following three types:

- **Material or product type**: It records what happens to the material or product. For example, change in location or operation, transportation, etc. of the material or product.

- **Man type**: It records all the activities of the worker or operator.

- **Machine type**: It indicates how the machine or equipment is used.
3. **Man-machine charts**: This chart is a variation of multiple activity charts and illustrates the operation and delays of the operator and the machine which is being operated.

4. **Activity charts**: In this chart, the activities of more than one subject, may be a worker, equipment or machines, are recorded on a common time frame to show their interrelationship.

### 6.4.2 Charts for Analysis of Equipment Utilisation

- For the purpose of further analysis of the production process, it is desirable to divide and subdivide the whole production process into a number of sub-processes. It will help in analysing in detail the activities of man and machine in terms of time taken and movements involved. In other words, the time and motion study is systematically conducted.
- These charts are useful for taking the necessary steps to reduce the idle time both for man and machine. This helps in achieving the maximum utilisation of available inputs. These charts are also known as Activity Charts or Man Machine Charts.

### 6.4.3 Master Scheduling

- Master scheduling is considered to be the foundation for planning & controlling the production activities. On the basis of earlier production programmes in terms of sales, delivery date, etc., a master schedule is prepared. On this basis, the feasibility of a new production programme is evaluated.
- A master schedule is a list showing how many of each item will be made in each period of time. It provides necessary statistical information to meet the delivery and job replacement through maximum utilisation of plant and other resources.
- It is also described as a time table of the production process indicating the starting and finishing periods of various activities or operations relating to the production of the desired goods and services.
- While preparing the master schedule information regarding market forecasts, customer orders, inventory levels, facility loading & capacity available, etc., is taken into consideration.
- Market schedule is also described as a plan for future production of finished goods over a short period of time covering few weeks or months. It serves as a crucial link between production and marketing.
- The objectives of master production scheduling are to:
  - schedule the final products to be completed in time as promised to the customers
  - supply the goods & services with minimum cost & time
  - avoid overloading as well as underloading of the production facilities, storing, etc., so that the installed capacity can be used more efficiently and the output produced is at the lowest costs

**Functions of master schedule**

- The master plan not only formalises the production plan, but also converts material or into material and capacity requirements. It helps to estimate the various resources, equipments required for each job.
- It also facilitates in deriving the production and inventory system by setting production targets. The main functions of the master schedule are to:
  - develop derivative plans for specific final products process
  - estimate material requirements
  - estimate capacity and labour requirements
  - maintain the priorities
  - achieve optimum use of resources and installed capacities
- Thus it may be concluded that, if the master schedule is worked out systematically then it results into optimum use of resources, minimisation of cost of production.
Summary

- The production planning and control provides a connection between the manufacturing unit and the sales unit of the company. The sequence of operations which involves men, materials and machines has to be properly analysed in a systematic manner so that productive planning can be successful. This systematic implementation of process in an organisation is known as production order.

- The main objectives and functions of production order are to provide the necessary information about—production design; desired output, duration and sequence of various activities. Secondly, to provide the basis for evaluating the performance of various components of production process in terms of quality, time and cost. And lastly, to help in the operation of production control.

- In batch and mass production units, batch numbers are prepared for the respective work orders, while in continuous production units, where only one product is manufactured, no work orders needs to be prepared.

- The charts used frequently for production order are—process analysis charts, charts for analysis of equipment utilisation, and master schedule.

- Operation process charts gives on overall view of the whole process by recording the sequence of the main operation and inspections.

- Flow process chart is graphic representation of the sequence of all the operations, transportation, inspection delays, storing, and so on.

- A master schedule is a list showing how many of each item will be made in particular period of time. The main objectives of master production scheduling are to schedule the final products to be completed in time as promised to the customers, supply the goods & services with minimum cost & time, avoid over loading as well as under loading of the production facilities, storing and so on.

Reference


Recommended Reading

Self Assessment

1. The systematic arrangement of the organisation is known as ______________.
   a. production order
   b. production job
   c. production analysis
   d. production sequence

2. The production planning and control provides a connection between the ___________ and the sales unit of the company:
   a. staff
   b. manufacturing
   c. order
   d. accounting

3. In _________ and mass production units, batch numbers are prepared for the respective work orders.
   a. job
   b. flow
   c. batch
   d. group

4. In a _________ production unit, customer orders are directly converted into job orders.
   a. job analysis
   b. job sequence
   c. job record
   d. job order

5. ___________ chart is graphic representation of the sequence of all the operations, transportation, inspection delays, storing, and so on, which may occur during a process.
   a. Flow process
   b. Job process
   c. Order process
   d. Gantt

6. Which of the following statement is true?
   a. Master process is considered as the foundation for planning & controlling the production activities.
   b. A master schedule is a list showing how many of each item will be made in particular period of time.
   c. The master plan only formalises the production plan.
   d. Market schedule is also described as a plan for future production of finished goods over a short period of time covering few weeks or months.
7. Which of the following statement is false?
   a. The production order is also known as the graphical representation of various activities performed by men, machines and materials of a manufacturing system.
   b. The production planning and control provide a connection between the manufacturing and the sales unit of the company.
   c. In continuous production units where only one product is manufactured work orders are essential to be prepared.
   d. The main objective of master production scheduling is to schedule the final products to be completed in time as promised to the customers.

8. Which of the following flow process charts records all the activities of the worker or operator?
   a. Machine type
   b. Job type
   c. Material type
   d. Man type

9. Which of the following charts indicates how the machine or equipment is used?
   a. Machine type
   b. Man type
   c. Inflow type
   d. Process type

10. Which of the following charts are used to record what happens to the material or product?
    a. Job type
    b. Material or Product Type
    c. Mass type
    d. Volume type
Chapter VII
Production Scheduling and Loading

Aim
The aim of this chapter is to:

- define production scheduling and state its objectives
- enlist and explain types of scheduling
- elucidate various techniques of scheduling

Objectives
The objectives of this chapter are to:

- understand meaning of production scheduling, its scope and objectives
- classify scheduling in various types
- analyse types and techniques of scheduling

Learning outcome
At the end of this chapter, the students should be able to:

- define production scheduling and state its objectives
- identify types of scheduling applied
- recall different techniques of scheduling
7.1 Introduction
Scheduling is an important tool for manufacturing, having major impact on the productivity of a process. In a manufacturing process, the purpose of scheduling is to reduce the production time and costs by informing a production facility with—when to begin, with which staff, and on which equipments.

Scheduling has yet another objective to fulfil—confirm or revise the tentative delivery date promised in the original quotation. At times, while scheduling a work order, it is discovered that delivery date originally and tentatively promised are not met. This may be due to unavailability of materials or due to increased plant loading while the customer was deciding whether or not to award the quoted job to this company. Determination of the realistic delivery date can only be made after detailed and firm scheduling.

Production scheduling
Production scheduling is the process of creating “to-do” lists or a dispatch list for the organisation. As part of a larger planning and scheduling process, production scheduling is essential for the appropriate functioning of any manufacturing enterprise. Production scheduling aims to maximise the efficiency of the operation and reduce costs.

7.2 Objectives and Scope of Scheduling

Objectives
Following are the objectives of scheduling:

• plan the work sequentially to deliver order on scheduled date
• minimise the production cost
• have minimum through put time for having better utilisation of recourses
• minimise idle time of machines and labour and to make maximum use of plant
• prevent unbalanced allocation of time among various departments and work centres
• minimise the storage cost
• reduce the working capital investment in inventories of semi-processed materials

Scope
The scope of scheduling system varies with the type of layout and the type of job. Generally, scheduling involves loading of machines and work centres and referred to as ‘scheduling and loading’.

The main areas covered by scheduling are:

• assigning a job to a particular work centre or machine
• to fix the time of assignment of job and its completion
• allocating necessary resources such as materials manpower and so on
• to decide about the time sequence of operations
• to carry out the feedback and control functions to take care of deviations

7.3 Types of Scheduling
Different types of scheduling include:

• **Operation scheduling:** It determines the total time required to do a piece of work with a given process or machine. It indicates the time required to perform each operation and also other details like materials machine, labour, resource etc. required for each operation.

• **Master scheduling:** It is a list indicating how much of each item is to be manufactured in each period of time in the future.

• **Sequential scheduling:** It defines a sequence for a multi-product plant which passes through a number of departments.
7.4 Techniques of Scheduling

The following techniques are used for scheduling:

- Gantt Chart
- Johnson’s Two Machine Algorithm
- Index Method
- CPM and PERT Techniques
- The Run out Approach

7.4.1 Gantt Charts

Gantt Charts are useful tools for analysing and planning more complex projects. They can be used for activities like:

- plan out the tasks that need to be complete
- give a basis for scheduling when these tasks will be carried out
- allow planning of allocation of resources needed to complete the project
- help to work out the critical path for a project where you must complete it by a specific date

When a project is in progress, Gantt Charts help to supervise whether the project is on schedule. If it is not, it suggests the remedial action necessary to put it back on schedule.

Gantt charts are of two types:
1. **Gantt load chart** graphically displays the work loads on each machine or work centre.
2. **Gantt scheduling or progress chart** illustrates the progress of the assigned task

![Table 8.1 Gantt scheduling chart](image)

Table 8.1 Gantt scheduling chart

Few limitations of Gantt chart are:

- The relationship between various operations can not be shown in the chart.
- When certain modifications are made in a schedule, it is very difficult to incorporate the corresponding changes in the chart.

7.4.2 Johnson’s Two Machine Algorithm

- S. M. Johnson developed a rule for scheduling when the sequence of operations involves two machines and there are ‘n’ jobs to be processed.
- The rule provides guidelines to minimise the total completion time for ‘n’ jobs, by minimising the total idle time of the machines.
- According to Johnson’s rules, the job operations are arranged on the two machines in the order of their processing time, depending on shortest processing time and so forth.
7.4.3 Index Method

- "Index Method’ is a technique that can be effectively utilised for the purpose of loading and the allocation of different jobs to different machines. Normally, orders are assigned to the best machine till it is loaded to its full capacity, remaining orders to the next best machine and so on, more or less on the principle of “first come first assigned.”
- This method, however, does not result in optimum loading. A better method of machine loading, especially when there are sufficient orders and reasonable choice of machines, is to assign orders to the machines on the basis of relative effectiveness of the machines.
- Index method is a very simple technique which provides considerable improvement over the conventional methods of loading.

7.4.4 CPM and PERT Techniques

- Critical Path Method (CPM) is another useful technique to determine the schedule of the activities of projects. Though Gantt charts are also used extensively to plan, schedule and control many business activities but they, however, have serious limitations if the projects are complex.
- This technique overcomes these deficiencies of the Gantt chart. It is used for scheduling large projects where the relationships between different activities of the project are more complicated than that of a production job requiring a simple chain of activities to be completed one after another.
- CPM can be used to schedule the activities of simple projects like overhauling of a machine, purchase and installation of a new machine, construction of a small shed. And at the other extreme end, it can be used for large complicated projects like design, production and testing of prototype of an aircraft requiring co-ordination, scheduling and control of activities of many different specialist teams, sub-contractor and purchasing agents.
- The Programme Evaluation Review Technique (PERT) technique provides a measure of the probability of completing the project by the scheduled date. In PERT, the assessment of the end event of the project is related to the degree of uncertainty that is associated with the three time estimates.

7.4.5 The Run Out Approach

- The Run out approach is applied to the process of production, which is then geared up to inventory level. It is demand oriented and aims at minimising stock-outs by assigning highest priority to those items which are likely to run out.
- The run out time for each time can be calculated and a monthly forecast upon the future needs can be developed. Finally, the total number of months that may elapse before the total inventory will run out is calculated. This method is simple, easy, and economical. It helps in minimizing stock outs and contributes towards improving the consumer service. Hence, it is widely used in modern manufacturing organisations.
Summary

- Scheduling is a process of deciding when each operation of production process is to be undertaken. Thus, it involves preparing a schedule for manufacturing activities indicating the time required for the production at each stage.
- Production scheduling is essential for the appropriate functioning of any manufacturing enterprise.
- The main objectives of production scheduling are to deliver order on scheduled date, minimise the production and storage cost, prevent unbalanced allocation of time and so on.
- Techniques that are used for scheduling include Gantt chart, Johnson’s Two Machine Algorithm, Index method, CPM and PERT techniques and the Run out Approach.
- Gantt Charts is one of the principle tools used in scheduling and loading. It helps to supervise whether the project is running on schedule. The relationship between various operations cannot be shown in Gantt chart.
- Johnson’s two machine algorithm is a useful concept in scheduling when the operation sequence involves two machines and the processing time depends on the sequence in which the jobs are loaded.
- Index Method is a technique that can be effectively utilised for the purpose of loading and the allocation of different jobs to different machines.
- Critical Path Analysis is used to determine the schedule of the activities of projects. The PERT technique provides a measure of the probability of completing the project by the scheduled date. The Run out approach is applied to the process of production, which is then geared up to inventory level.

Reference


Recommended Reading

1. ___________ is an important tool for manufacturing, having major impact on the productivity of a process:
   a. Scheduling
   b. Ordering
   c. Sequencing
   d. Conceptualisation

2. Determination of the realistic ___________ can only be made after detailed and firm scheduling.
   a. order
   b. delivery date
   c. process
   d. production

3. ___________ scheduling aims to maximise the efficiency of the operation and reduce cost.
   a. Development
   b. Order
   c. Production
   d. Material

4. The run out approach is applied to the process of production, which is geared up to ___________ level.
   a. delivery
   b. management
   c. top
   d. inventory

5. The ___________ technique provides a measure of the probability of completing the project by the scheduled date:
   a. PERT
   b. CMP
   c. Index method
   d. Gantt charts

6. ___________ is another useful technique to determine the schedule of the activities of projects.
   a. Crucial Path Method
   b. Critical Path Analysis
   c. Critical Course Analysis
   d. Critical Path Study

7. State which of the following is false.
   a. Scheduling has yet another objective to fulfil to confirm or revise the tentative delivery date promised in the original quotation.
   b. The PERT technique provides a measure of the probability of completing the project by the scheduled date.
   c. The scope of scheduling system does not vary with the type of layout and the type of job.
   d. The run out approach is applied to the process of production, which is geared up to inventory level.
8. State which of the following is false.
   a. Index method is a technique that can be effectively utilised for the purpose of loading and the allocation of different jobs to different machines.
   b. Index method is a very simple technique which provides considerable improvement over the conventional methods of loading.
   c. Gantt charts are used extensively to plan, schedule and control many business activities.
   d. The relationship between various operations can be shown in Gantt chart.

9. Which of the following is a type of scheduling?
   a. Operation
   b. Job
   c. Flow
   d. Order

10. Which of the following techniques is used for scheduling?
    a. Line diagram
    b. Gantt chart
    c. Pie chart
    d. Line graph
Chapter VIII

Types of Maintenance Management

**Aim**

The aim of this chapter is to:

- evaluate different types of maintenance management system
- elucidate objectives maintenance systems
- explain merits and demerits of each system

**Objectives**

The objectives of this chapter are to:

- classify different types of maintenance management system
- learn merits and demerits of different types of maintenance management system

**Learning outcome**

At the end of this chapter, the students should be able to:

- define types of maintenance management system
- identify merits and demerits of different maintenance management systems
8.1 Introduction

Maintenance Management is a systematic approach to planning, organising, monitoring and evaluating maintenance activities and their costs. A good maintenance management system coupled with knowledgeable and capable maintenance staff can prevent health and safety problems and environmental damage; yield longer asset life with fewer breakdowns; and result in lower operating costs and a higher quality of life.

Depending on the application and design, maintenance management systems may have various formats and procedures, e.g., various formats of work orders, reports, computer screens, etc., but the basic principles of all these systems are almost similar. Hereunder, different types of maintenance management systems are explained with their objectives, merits, demerits and so on.

8.2 Breakdown or Corrective Maintenance Management

- Corrective maintenance is undertaken whenever there is a breakdown of machinery and equipments leading to the work-stoppages. Hence, it is criticised as merely repair work. Under corrective maintenance, the maintenance department plays a passive role.
- As equipments fail to function during corrective maintenance, it is also called as – Shut down Maintenance.
- Some organisations adopt the approach of corrective maintenance for non critical equipments. It has been observed that the nature and time of breakdown of any type of equipment is a random phenomenon, hence it cannot be completely eliminated even by most efficient preventive maintenance.
- The corrective maintenance policy is suitable and economical for those types of equipments which have relatively less downtime and repair costs. It is easier to administer and needs relatively less staff.
- Even if the firm adopts the policy of preventive maintenance, still, corrective maintenance work is necessary reasons like:
  - rehabilitate or recondition of machinery and equipment
  - replace major depreciated parts
  - correct manufacturing because of the failure of certain parts
  - improve reliability of equipment by making essential changes in design, process and so on
- The breakdown maintenance strategy may be adopted by analysing the causes of breakdown. These causes include:
  - negligence of minor faults
  - failure to identify and replace worn out parts
  - neglected or inefficient cooling system
  - lack of lubrication
  - wide fluctuations in voltage
  - use of substandard or wrong fuel
  - negligence towards increase vibration, sound and so on

Objectives of corrective maintenance management

The main objectives of corrective maintenance are to:
- control the cost of operation of repair shops
- reduce investments in replacement spare parts
- repair an equipment as early as possible to minimise interruption in production
- control cost of repairs through minimising labour costs
- reduce investment in replacement spare machines or stand by machines
- carryout appropriate amount of repairs at each malfunction or breakdown
Disadvantages

- Failure of machinery and equipment may cause serious accidents leading to losses and lower morale.
- It leads to dislocation of the whole production process and may cause excessive delays and huge reduction in output and increase in production costs.
- The management has to pay wages and incurs other costs in spite of stoppage in production, which may lead to heavy losses.
- It may lead to more wastage of materials.

Corrective maintenance policy is not applicable to those equipments which are regulated by statutory provisions like lifts, cranes, hoists, etc.

In spite of their disadvantages, the breakdown maintenance policy is followed by some organisation for equipments which have less repair costs and low downtime. Corrective maintenance is costly because the organisation has to incur expenditure on corrective maintenance and has to suffer huge losses due interruption of production.

8.3 Preventive Maintenance

- All machines and equipments deteriorate when they are used enough for the purpose of production. The deterioration of machinery results into changes in the dimension of various components and weakening of its members due to fatigue, impact and corrosion.
- When the machinery deteriorates:
  - it is unable to take specific loads
  - there is deterioration of quality and quantity of output produced by such machines
  - it leads to reduction in speed of the machinery
  - it tends to reduce the operational life of the machines
- If this process of deterioration is neglected, then it may not only increase the cost of production but also may lead to complete stoppage of machines due to breakdown of one or more parts of it.
- So it is desirable to adopt a sound maintenance policy and implement it effectively. Preventive maintenance is an activity undertaken to prevent breakdowns to reduce operating costs and improve quality and quantity of the output.
- Preventive maintenance involves following practices:
  - regular cleaning, greasing and oiling of moving parts
  - reduction in overloading of equipments or plant services
  - replacement of worn out parts before they fail to operate
  - periodic and regular over haling of the entire machine
  - those equipments, which are likely to fail suddenly, should be installed in duplicate e.g. pumps, transformers motors, compressors and so on.
  - for every critical or key machinery stand by or extra machinery should be provided

Objectives of preventive maintenance

The objectives of preventive maintenance are to:

- reduce unanticipated production interruptions by way of locating its cause and taking necessary steps to keep steady and continuous flow of production
- keep machinery and equipment in good working condition
- maintain the value of machinery and equipment by periodic inspection, repaint, overhauling and so on
- reduce the work content of maintenance jobs
- ensure safety of life and limbs of the workers
- increase reliability of machinery or equipment by promoting its availability. This is given by:
A = \frac{T}{(T_1 + T_2)}

Where A = Availability of machinery or equipment
T_1 = the cumulative time of operation in the normal working condition
T_2 = the cumulative down time

Advantages
- relatively lower production down-time on account of fewer breakdowns
- lower labour costs as overtime payment may be reduced for maintenance and repair workers
- the frequencies as well as magnitude of repairs are reduced
- the quality and quantity of output produced may increase and hence there will be less rejection of products, lower spoilage and better quality control
- a relatively lower requirement of stand-by equipment and machinery, which may reduce capital investment.
- improvement in spare parts control, which may result into minimum level of inventory
- it provides greater safety to workers
- it minimises the total maintenance costs
- it ultimately results into lower unit cost of production

The main disadvantage of this maintenance system is that of impossibility of standardisation, because every work performed by the maintenance department is entirely of different type. Secondly, preventive maintenance is relatively costly because of need of stocking huge maintenance inventory and it also needs frequent inspection and service.

8.4 Routine Maintenance

- It includes activities such as periodic inspection, lubrication, cleaning, repairs etc. of machinery and equipments after their service life. It includes tightening of the bolts, recharging of batteries, replacing light bulbs and tubes in the plant area etc.
- It is routine as it does not require any technical skill and it is repetitive in nature and has to be done more frequently than anticipatory inspection. Routine maintenance is classified in two categories;
  1. **Running maintenance**, where maintenance work is carried out while the equipment is in working stage, for example, greasing or lubricating the bearing when the machine is running.
  2. **Shut down maintenance**, where maintenance work is carried out only when the machinery or equipment is out of service i.e., repairing the machine due to its complete failure to do the normal job.

8.5 Predictive Maintenance

- Predictive maintenance is a modern concept having a bright future prospect. Maintenance problems arise in case of machinery equipment of mechanical design has a large number of moving parts.
- However, on account of rapid development of electronics and computer technology, modern machines have much less number of moving parts of mechanical design. Hence there is less wear and tear and thus less need of maintenance.
- The cost of maintenance can be reduced if an attempt is made to predict future failure in advance and carryout appropriate preventive measures. It helps in avoiding loss of production and prevent stocking of unnecessary inventory over longer period of time.
- As a result of faster technological progress in the modern times, more sophisticated testing equipments are now available to measure performance of plant “in situ.”
- Now there is no need to shut down the plant, just as screening of the human body, with the help of test equipment, the conditions of working parts of the machinery and plants can be easily assessed. This helps the maintenance manager to extend the working life of plant and machinery and increase time intervals between successive overhaul and servicing.
8.6 Planned Maintenance

- Breakdown or failure of a machine to operate does not occur in a planned manner but the maintenance work can be systematically planned well in advance. The planned maintenance is also called as scheduled or production maintenance.
- It includes inspection of all plant, machinery and equipments, building according to a predetermined schedule in order to provide service, overhaul, lubricating, repair, etc., before actual breakdown takes place.

Advantages

- provides procedures to plan, execute, monitor as well as control maintenance resources
- facilitates a systematic collection of materials before planning for the jobs
- offers a communication link between maintenance and operations
- provides a daily plan for front-line supervisors
- reduces the time required for critical shutdowns or overhauls
- minimises maintenance costs
- lessens emergency breakdowns

8.7 Total Productive Maintenance (TPM)

Total Productive Maintenance was first developed in Japan. It is a maintenance program involving a newly defined concept for maintaining plants and equipment. The goal of the TPM program is to increase production while, at the same time, increase employee morale and job satisfaction noticeably.

TPM brings maintenance into focus as a necessary and significant part of the business. It is no longer regarded as a non-profit activity. Down time for maintenance is scheduled as a part of the manufacturing day and, in some cases, as an integral part of the manufacturing process. The goal is to hold emergency and unscheduled maintenance to a minimum.

Objectives of TPM

- avoid wastage in a quickly changing economic environment
- reduce cost
- produce a low batch quantity at the earliest possible time
- goods sent to the customers must be non defective
Summary

- Maintenance management is a systematic approach to planning, organising, monitoring and evaluating maintenance activities and their costs. Depending on the application and design, maintenance management systems may have various formats and procedures.
- Corrective maintenance is undertaken whenever there is a breakdown of machinery and equipments leading to the work-stoppages.
- The corrective maintenance policy is suitable and economical for those types of equipments, which have relatively less downtime and repair costs.
- Preventive maintenance is an activity undertaken to prevent breakdowns to reduce operating costs and improve quality and quantity of the output.
- Routine maintenance includes activities such as periodic inspection, lubrication, cleaning, repairs etc. of machinery and equipments after their service life.
- The main disadvantage of preventive maintenance system is that of impossibility of standardization because every work performed by the maintenance department is entirely of different type.
- Planned maintenance aims at reducing machine stoppages due to sudden breaking down calling for emergency maintenance.
- Total Productive Maintenance (TPM) is a maintenance program which involves a newly defined concept for maintaining plants and equipment.

Reference


Recommended Reading

Self Assessment

1. The ____________ policy is suitable and economical for those types of equipments which have relatively less downtime and repair costs.
   a. corrective maintenance
   b. preventive maintenance
   c. predictive maintenance
   d. planned maintenance

2. The __________ maintenance strategy may be adopted by analyzing the causes of breakdown.
   a. preventive
   b. breakdown
   c. predictive
   d. planned

3. ____________ is an activity undertaken to prevent breakdowns, reduce operating costs and improve quality and quantity of the output.
   a. Breakdown maintenance
   b. Predictive maintenance
   c. Preventive maintenance
   d. Planned maintenance.

4. Which of the following is considered to have a bright future prospect?
   a. Breakdown maintenance
   b. Preventive maintenance
   c. Planned maintenance
   d. Predictive maintenance.

5. ____________ program involves a newly defined concept for maintaining plants and equipment.
   a. Total productive maintenance
   b. Preventive maintenance
   c. Planned maintenance
   d. Predictive maintenance

6. Which is a planned activity, so that the analyst can be aware of time and resources required for it?
   a. Planned maintenance
   b. Preventive maintenance
   c. Predictive maintenance
   d. Breakdown maintenance

7. Which of the following statement is false?
   a. Corrective maintenance management techniques are easier to administer and needs relatively less staff.
   b. The planned maintenance is also called as pre-production maintenance.
   c. The breakdown maintenance strategy may be adopted by analysing the causes of breakdown.
   d. Preventive maintenance is a planned activity so the analyst is aware of time and resources required for it.
8. Routine maintenance is classified into which of the following categories?
   a. Regular and preventive
   b. Primitive and anticipatory
   c. Running and shut-down
   d. Implicit and explicit

9. Total productive maintenance was developed in which of the following countries?
   a. Germany
   b. India
   c. USA
   d. Japan

10. Which of the following maintenance technique is relatively costly due to the need of stocking?
    a. Preventive maintenance
    b. Predictive maintenance
    c. Breakdown maintenance
    d. Planned maintenance
Chapter IX
Inspection & Quality Control

Aim
The aim of this chapter is to:
• explain meaning of inspection and quality control
• elucidate function and importance of inspection
• analyse steps in the inspection process
• clarify objectives and advantages of quality control
• explore the concept of statistical quality control

Objectives
The objectives of this chapter are to:
• classify types of inspection and quality control
• understand merits and demerits of each process
• learn about importance of quality control
• examine the meaning and importance of Statistical Quality Control

Learning outcome
At the end of this chapter, the students should be able to:
• recall the meaning, function and importance of inspection
• identify various methods of inspection and quality control
• understand meaning, objectives and advantages of quality control
• grasp the concept of statistical quality control
9.1 Introduction

Inspection is an important tool of quality control, which aims at controlling the quality of the product. The quality inspection is carried out to protect the standard and quality of the product by comparing the materials, workmanship and products with set of standards. It is a method adopted by the examiner to find out how far the total work done confirms the pre-determined standards. If he/she confirms the standards then it will be accepted, otherwise it is rejected. Thus, inspection is said to be a sorting process on the basis of which products can be classified into acceptable or unacceptable ones.

9.2 Inspection

Kimball defined inspection as, “The art of comparing materials, products or performances with established standards.”

There cannot be intelligent inspection without definite standards. Items that are inspected—some will fall outside the liberal allowance of variation from the standards, some will be well within the limits of error and others will be very close to the limits. “Inspection is the art of selecting these three classes of product, those which will be satisfactory for the work.”

Spriegel defined inspection as, “The process of measuring the qualities of a product or services in terms of established standards.”

Afford and Beatty stated that, “Inspection is the art of applying tests, preferably by the aid of measuring appliances to observe whether a given item or product is within the specified limits of variability.”

9.2.1 Inspection Vs. Quality Control

Inspection and quality control are closely related, but they also differ in several respects as follows:

<table>
<thead>
<tr>
<th>Inspection</th>
<th>Quality control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection is technique used to achieve the objective of quality control.</td>
<td>Quality control emphasises producing better quality products at minimum cost.</td>
</tr>
<tr>
<td>Inspection aims at the application of tests using measuring devices to compare the products with standards. Thus, inspection is the process of finding out whether the product is acceptable or not by comparing it with the limits of specified variability’s.</td>
<td>Quality control aims at finding out the causes of variation in characteristics of the products and to suggest measures to reduce these variations.</td>
</tr>
<tr>
<td>Inspection deals with actual examination of the products for quality characteristics required for quality control.</td>
<td>Quality control deals with when, what and how much to inspect.</td>
</tr>
</tbody>
</table>

Table 9.1 Difference between inspection and quality control

In earlier days, inspection was considered as a part of quality control but the development of statistical quality control concepts there two aspects are now considered as separate functions.

9.2.2 Objectives of Inspection

The main objectives of inspection are as follows:

- **Maintenance of quality**: The main objective of inspection is to maintain the quality of the product. For this purpose, materials, products, men, machine and tools are compared with the established standards. The items
which confirm to the specifications or are within the satisfactory limits are accepted, others lying beyond the acceptable standard limits are rejected.

- **Improving quality of the products:** By way of comparing the quality of the products with the set of standards, the defective items and reasons behind them are identified. These defects are then removed so as to make necessary adjustments for future development and maintenance of the quality of the product. It helps to improve the goodwill about the organisation.

- **Minimisation of costs:** As the inspection process starts with examining the raw materials, defective raw materials is rejected right from the initial stages. This helps the organisation to minimise losses and also to reduce the cost of production of the goods.

- **To detect sources of weaknesses:** The inspection process enables the management to know the sources that adversely affect the quality and quantity of the products. It enables the organisation to meet the consumer demands effectively and contribute towards maximisation of consumer satisfaction.

**9.2.3 Steps in the Inspection Process**
The main steps involved in the process of inspection are as follows:
1. Identify most important characteristics of the quality of the items which are to be inspected i.e., what to inspect?
2. Decide when and where the inspection should take place i.e., when and where to inspect?
3. Find out what size of the sample should be selected for detailed inspection so that the sample size is a proper representation of the material/items under study i.e., what should be the sample size?
4. Develop a sampling scheme for actually selecting the items from the lot i.e., how to select the sample?
5. Define specification limits for the acceptance or rejection of the items i.e., to fix limits of tolerance of deviation from the standards.

**9.2.4 Functions of Inspection**
The main functions of inspection department are to:
- develop & maintain the specified standards of the quality of the product produced
- develop methods and techniques to carry out inspection at minimum cost
- separate defective products and send it for re-operation
- maintain tools and equipments of inspection in good condition
- make an attempt to detect the defects at the source so as to reduce scraps and defective products
- advise operating the workforce whenever difficulties in the production process arise
- report top management about the sources of manufacturing problems

**9.2.5 Problems of Inspection**
During the process of inspection in manufacturing organisation, the following problems are to be addressed:

**Where to inspect?**
A decision has to be taken about where to hold inspection. Generally, inspection is carried out at the vendors or the buyers place. Inspection is carried how the following three stages:
- in process inspection
- final inspection
- post sales quality evaluation

**When to inspect?**
It is necessary that items should be inspected at every place whenever there is a possibility of passing out the defects.
How much to inspect?
The nature of the product and the extent of precision have to be taken in to consideration while deciding about how much to inspect. If there is a large scope for variation then 100% products need to be inspected, otherwise 10 to 25% sample may be considered adequate.

How to inspect?
There are two methods that are adopted for inspection:

- Under variable inspection method - Samples are chosen out from the lot and their sizes, weights, measures, etc., characteristics are compared with standard set.
- Under attribute method - The critical attributes are compared with the standards and whenever essential properties are not found, the lot is rejected.

Cost of inspection?
As the cost of inspection is the part of the total cost of production, the producer has to keep the cost of inspection at minimum without surrendering the quality of the product otherwise inspection has no meaning. From the point of view of maintaining desired level of profitability the necessary decision has to be taken in time.

9.3 Types of Inspection
The important types of inspection are described below:

9.3.1 Centralised or Crib Inspection
According to this scheme, there is only one inspection unit for the organisation as a whole or, each section may have one inspection unit to inspect the items produces by that unit. The items are shifted to the inspection unit. The inspection team is skilled and experienced and uses advanced, sophisticated and reliable instruments and techniques for quality checking. The main idea is to keep inspection unit separate from manufacturing unit.

Advantages
- reliable and accurate
- no possibility of collusion between production men and inspectors
- priorities of inspection can be planned according to loads on production department
- machine sites do not face the problem of work awaiting inspection, giving operators, more time for free movement
- facilitates usage of more sophisticated equipments and techniques for inspection
- provides control of accuracy of inspection gauge
- gives better environment for inspection

9.3.2 Decentralised or Floor Inspection
Under this inspection system, semi finished goods are inspected either on the machine or in the production line. The handling activities are hence reduced and defects in products can be located immediately. It requires inspectors fully equipped with skills and equipments to visit the work site and check the production on the spot.

Advantages
- reduces chances of handling
- saves time and cost of transporting products to inspection department for inspection
- enables to locate faults immediately and hence tends to reduce the scrape
- with passage of time, the machine operators get trained to maintain quality and hence inspection may be reduced
- enables to keep work flow as delays for inspection are reduced
- suitable for heavy and large jobs
Disadvantages

- less freedom of movement to the operator
- inspection work may not have sufficient space
- flow of work over machines may be disturbed due to accumulation of work on the floor.
- work in progress gets scattered causing difficulties in inspection
- inspection with sophisticated and high precision instruments cannot be performed on the shop floor
- floor conditions with dust, vibrations, noise, etc., are not suitable for inspection

The choice of the method of inspection strategy depends on the nature of the product, volume of the work, quality awareness of the enterprise, production process, etc. Sometimes, a combination of centralised and shop floor inspection may be adopted to maintain higher quality standards.

9.4 Quality Control

Quality is the sum of attributes or properties of a product, which are expressed in terms of length, colour, specific gravity, etc. It is that characteristic or a combination of characteristics that distinguishes one article from the other.

According to Spriegel, “The quality of a product may be defined as a sum of a number of related characteristics such as shape, dimension, composition, strength, weight, adjustment, finish and colour.”

Alford and Beatty stated that, “Quality control refers to the systematic control of those variables encountered in a manufacturing process which affect the excellence of the end product. Such variables result from the application of materials, men, machines and manufacturing conditions.”

Control implies the comparison of the actual results or finished products with the predetermined standards and specifications. It aims at locating deviations and removing them. Thus, control is the correction in quality of the product having deviations that are present when compared to the standards. Hence, quality control is a technique of scientific management having the objective of improving industrial efficiency by concentrating on better standards of quality and on controls to ensure that the standards are properly maintained.

9.4.1 Objectives of Quality Control

The prime objectives of doing a quality control check are to:

- assess the quality of raw materials, semi-finished and finished goods at different stages during the process of production
- check whether the product conforms to the predetermined standards and specifications, and also whether it satisfies the customers or not
- identify the causes of deviation from the standards and remedial steps to remove them
- suggest improvements in the quality of goods through new methods, use of machinery, etc.
- develop quality consciousness in various sections of the production department
- assess various techniques of quality control, methods and processes of production and suggest improvements in them to make them more effective
- reduce wastages of all types and idle time in men, machinery and so on

9.4.2 Advantages or Importance of Quality Control

Quality control generates advantages both for the organisation and consumers. A quality product helps the consumers to maximise their satisfaction and hence the demand for such products increases rapidly. Quality control facilitates an organisation to:
• increase goodwill, profitability and market share of the company
• reduce cost of production
• aim at maximum utilisation of resources most economically
• increase the morale of employees
• maximise consumers’ satisfaction
• increase market share and sales revenue
• find out causes of variations and steps to correct them

9.5 Statistical Quality Control (SQC)

The Statistical Quality Control is the application of statistical techniques to decide whether to accept or reject the product produced or to control the process of production to maintain product quality, while the product is being produced. The former is known as acceptance sampling while the latter is known as Statistical Process Control (SPC).

Acceptance sampling is based upon the assumption that, as 100% inspection is time consuming and costly, it is possible to select scientifically a part of the lot or sample in such a way that it represents all the characteristics of the lot. It is the process of evaluating a portion of the product material in a lot for the purpose of accepting or rejecting the lot as, either conforming or not conforming to quality specifications. Acceptance sampling implies selection of a sample and carefully inspecting it to identify defects. After inspection if any defects are found the lot is rejected, but, if the number of defects is small, it may be accepted.

Statistical Process Control (SPC) is an effective method of monitoring a process through the use of control charts. Much of its power lies in the ability to monitor both process centre and its variation about that centre. By collecting data from samples at various points within the process, variations in the process that may affect the quality of the end product or service can be detected and corrected, thus reducing waste as well as the likelihood that problems will be passed on to the customer. It has an emphasis on early detection and prevention of problems.

9.5.1 Advantages of SQC

Following are several advantages of SQC:
• helps in preventing defects. The causes giving rise to deviations from standards are detected and removed thus reworking, rejection and scrap are avoided
• helps in avoiding risk of accepting a bad lot
• reduces the task of inspecting the whole lot
• helps in maintaining high standards of quality and promotes goodwill about the organisation
• aims at reducing inspection expenses so as to produce the final product at minimum cost
• standard quality helps in maintaining standard price
• promotes feeling of responsibility among the workers

9.6 Control Chart

The use of control chart in production system was introduced by Shewhart in 1924. The main aim of process control is to develop the system to differentiate between the variation due to chance causes and assignable causes. Once it is known, then assignable causes can be eliminated so that the quality of the product can be improved. The main tool used for this purpose is the control chart.

Representation of control chart
• A control chart is graphical representation of the inspection results of the samples of the products. It includes carefully worked out statistical limits that helps indiscriminating between random variable and assignable variables.
• It has three lines, an upper control limit, a central line and the lower control limit. While constructing a control chart, time is indicated on X axis and quality characteristics are of product on Y axis. The control parameters indicating upper control limit, central line and the lower control limit are shown by horizontal lines. The central line indicates the mean value of the quality characteristics.

• The upper control limit is shown at a distance of 3 standard deviations above the central line and the lower control limit is shown at 3 standard deviations below the central line. The samples of fixed size are taken at regular interval of time and these samples are inspected for required characteristics.

![Control Chart Graph](image)

**Fig. 9.1 Sample of control chart graph**

• The sample values are plotted on graph with respect to time. Then the positions of the points on the graph are studied.

• As long as the sample points lie within the control limits, the process indicates that it is under control. Any variations that are noticed arising on account of chance causes are hence not considered as serious in nature.

• The points which lie beyond the control limits indicate loss of quality mainly on account of assignable causes. These causes are identified and corrected immediately.

### 9.6.1 Types of Control Chart

Control charts are generally classified in two categories:

- control chart for variable
- control chart for attributes

#### 1. Control chart for variable

When the quality characteristics are subject to direct quantitative measurement, then the control can be exercised by examining the variables. So the control chart is called as chart for variables, e.g. diameter of the screw or other physical characteristics. These characteristics generally follow normal distribution. Hence $M + 3\sigma$ limits covers about 99.73 % of the observations.

There are two types of control chart for variables, which are commonly used:

**Control chart for mean**

Assuming that variability of characteristics is under control, there are four possibilities as discussed below,

- Standards are known i.e. $M$ and $0$ are given:
  
  When the standards are given, the control charts are drawn to find out whether the observed values of the characteristics differ from the standard or not. If $M$ & $S$ are the standard values of mean and deviation and if each subgroup is of sample size $n$ then according to sampling theory the standard deviation of the means of sample of size $n$ is given by $a/(Vn)^{1/2}$
Thus,
Upper control limit = \( M + 3\left(\frac{a}{\sqrt{Vn}}\right)^2 \)
Control limit = \( M \)
Lower control limit = \( M - 3\left(\frac{a}{\sqrt{Vn}}\right)^2 \)

- When mean is unknown but \( a \) is known:
The mean of the population can be estimated from the grand mean of the all the samples. If \( x_1, x_2, x_3, x_k \) are the means of the quality characteristics in ‘k’ samples then the grand mean is given by,
\[
X = \frac{x_1 + x_2 + x_3 + \ldots + x_k}{k}
\]
Then the control limits will be given as below:
Control limit = \( X \)
Upper control limit = \( X + 3\left(\frac{a}{\sqrt{Vn}}\right) \)
Lower control limit = \( X - 3\left(\frac{a}{\sqrt{Vn}}\right) \)

- When mean is known but ‘\( a \)’ is not known:
Under such condition range ‘R’ is used as measurement of dispersion, because it is easy to calculate and it is also closely related to standard deviation. In case of very large samples the distribution of the range tends to normal.

If range ‘R’ is the range of the observation in sample then the average range over all the ‘k’ samples is given by:
\[
R = \frac{R_1 + R_2 + R_3 + R_k}{k}
\]
The standard deviation is given by \( R/d_2 \) gives the standard deviation.
Where,
\[
d_2 \text{ is a constant depending upon the size of each subgroup of sample ‘n’}.
\]
The standard values of \( d_2 \) for various sample sizes can be read from table of control charts. Then the control limits will be given as below:
Control limit = \( M \)
Upper control limit = \( M + 3(R / d_2) = M + A R \)
Lower control limit = \( M - 3(R / d_2) = M - A R \)
Where,
\[
A = \frac{3}{d_2}. \text{ (Standard tables for } A \text{ values are also available.)}
\]

- When both \( M \) & ‘\( a \)’ are unknown:
Hence ‘\( M \)’ can be estimated from ‘\( X \)’ and \( a \) can be estimated by ‘\( R d_2 \)’. The various control limits will be as below:
Control limit = \( X \)
Upper control limit = \( X + 3(R / d_2) = X + A R \)
Lower control limit = \( X - 3(R / d_2) = M - A R \) \( \sim \text{ Where } A = \frac{3}{d_2}. \)

**Control chart for range (R Chart)**
There may be two situations:

(I) ‘\( a \)’ is known then,
Control limit = \( d_2 a \)
Upper control limit = \( d_2 a + 3 d_3 a \)
Lower control limit = \( d_2 a - 3 d_3 a \)
Where, \( d_2 \) and \( d_3 \) for given n sample can be obtained from standard tables
(II) ‘a’ is unknown then, ‘a’ is estimated with the help of range and is given by $R/d$. Hence

Upper control limit = $R + 3 \left( d \frac{1}{d^2} \right) \times R = R(1 + 3dWd_4)D$ 
Control limit = $R$
Lower control limit = $R - 3 \left( d \frac{1}{d^2} \right) \times R = R(1 - 3dWd_4)D$ 

Where $D_3 = (1 - 3d_3)/(d_2)$ and $D_4 = (1 + 3d_4)/(d_2)$ can be obtained for given $n$ from the standard tables that are available.

2. Control charts for attributes

In case of many manufacturing systems quality characteristics are not quantitatively measurable, so the items can be classified as good or bad with respect to the quality characteristics. The item may be classified as desirable or undesirable or merely by yes or no. Characteristics, simple examination and careful observation are sufficient to arrive at such a conclusion. Under such conditions, the proportion of defective items in each subgroup or lot hence, ‘$p$’ = No. of defective items found in a lot / Total no. of items inspected in the lot. So ‘$p$’ is known as fraction defective in the lot.

The behaviour of Binomial samples can be assumed to follow normal distribution and normal tables can be used to determine the control limits.

- ‘P’ and ‘np’ charts:
  When ‘$k$’ samples of size ‘$n$’ are taken from a population with proportion of detectives ‘$p$’ which is known standard, then the control limits of the control chart for fraction detectives i.e. ‘$p$’ chart is given by:
  
  Control limit = ‘$p$’
  Upper control limit = $p + 3 \sqrt{pQ/n}$
  Lower control limit = $p - 3 \sqrt{pQ/n}$

- And the limits for control chart for number of defectives i.e. ‘np’ chart are given by:
  Control limit = ‘np’
  Upper control limit = $np + 3 \sqrt{npQ}$
  Lower control limit = $np - 3 \sqrt{npQ}$
  Where $Q = 1 - p$
Summary

- Inspection is an important tool of quality control that aims at controlling the quality of the product. It is said to be a sorting process on basis of which products can be classified into acceptable or unacceptable ones.

- Inspection and quality control are closely related but they differ in several respects. The main objectives of inspection are detecting sources of weaknesses, minimising costs, improving quality of the products, maintaining the quality and the likes.

- As the cost of inspection is the part of the total cost of production, the producer has to keep the cost of inspection at minimum without surrendering the quality of the product, otherwise inspection has no meaning.

- The main types of inspection methods are centralised or crib inspection and decentralised or floor inspection.

- The choice of the method of inspection strategy depends on the nature of the product, volume of the work, quality awareness of the enterprise and production process.

- Quality is the sum of attributes or properties of a product, which are expressed in terms of length, colour, specific gravity etc. Quality control is a technique of scientific management having the objective of improving industrial efficiency by concentrating on better standards of quality and on controls to ensure that the standards are properly maintained.

- The SQC is the application of statistical techniques to decide whether to accept or reject the product produced or to control the process of production to maintain product quality, while the product is being produced.

- The main aim of process control is to develop the system to differentiate between the variation due to chance causes and assignable causes. Once it is known, then assignable causes can be eliminated so that the quality of the product can be improved. The main tool used for this purpose is the control chart.

- A control chart is graphical representation of the inspection results of the samples of the products. It includes carefully worked out statistical limits that helps indiscriminating between random variable and assignable variables.

Reference


Recommended Reading


Self Assessment

1. __________ is an important tool of quality control that aims at controlling the quality of the product.
   a. Inspection  
   b. Enquiry  
   c. Quality check  
   d. Introduction

2. Under which system semi finished goods are inspected either on the machine or in the production line?
   a. Statistical quality control  
   b. Decentralised or floor inspection  
   c. Centralised or Crib Inspection  
   d. Control Chart

3. __________ is the sum of attributes or properties of a product, which are expressed in terms of length, colour, specific gravity, etc.
   a. Quantity  
   b. Capacity  
   c. Quality  
   d. Ability

4. __________ implies selection of a sample and carefully inspecting it to identity defects.
   a. Exception sampling  
   b. External sampling  
   c. Internal sampling  
   d. Acceptance sampling

5. A __________ has three lines, an upper control limit, a central line and the lower control limit.
   a. control chart  
   b. control graph  
   c. index graph  
   d. index chart

6. __________ generates advantages both for the organisation and consumers.
   a. Quality check  
   b. Quality control  
   c. Quality analysis  
   d. Quality work

7. Which of the following is true?
   a. A control chart is pictorial representation of the inspection results of the samples of the defective products.  
   b. A control chart is graphical representation of the inspection results of the samples of the raw material.  
   c. A control chart is graphical representation of the inspection results of the samples of the products.  
   d. A control chart is graphical representation of the feedback results of the samples of the products.
8. Which of the following is false?
   a. Quality is the sum of attributes or properties of a product, which are expressed in terms of length, colour, specific gravity, etc.
   b. A control chart has three lines, an upper control limit, a central line and the lower control limit.
   c. Centralised inspection is likely to be more reliable and accurate.
   d. Exception sampling implies selection of a sample and carefully inspecting it to identify defects.

9. Who of the following defined inspection as the process of measuring the qualities of a product or services in terms of established standards?
   a. Kimball
   b. Spiegel
   c. Afford and Beatty
   d. T. Fayol

10. Who of the following defined inspection as, the art of comparing materials, products or performances with established standards?
    a. Kimball
    b. T.Fayol
    c. Afford and Beatty
    d. Spiegel
Chapter X
Work Measurement & its Techniques

Aim
The aim of this chapter is to:

• explain the meaning and importance of work measurement
• explore objectives of work measurement
• enlist elements of work measurement and its types
• explore different techniques of work measurement

Objectives
The objectives of this chapter are to:

• understand the objectives and advantages of work measurement
• elucidate types of elements of work measurement
• enlist and explain types of measurement techniques

Learning outcome
At the end of this chapter, the students should be able to understand:

• meaning, objectives and benefits of work measurement
• techniques of work measurement
• merits and demerits of different techniques of work measurement
10.1 Introduction
Work measurement is mainly concerned with the determination of the total time required to perform a unit of work. It is defined 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.

The amount of time required to complete a given job is expressed as time standard, work standard, labour standard, production standard or standard time. The standard time is the amount of time a qualified worker, working at a normal rate of speed, will require to perform the specified task. It is expressed in terms of minutes per unit or output per hour.

10.2 Objectives of Work Measurement
Work measurement aims at achieving the following objectives:

- fix the standard time for each job scientifically, which helps to workout realistic schedules and manpower requirements
- carryout a sound comparison of alternative methods on the basis of time
- develop improved planning and control of activities or operations
- promote more efficient manning of the plant
- generate effective incentive scheme by linking them with target times
- develop a reliable basis for the control of labour costs
- achieve proper balancing in work distribution
- provide basis for forecasting future manpower and related costs

10.3 Elements of Work Measurement
An element is a distinct part of a specified job selected for convenience by way of observation, measurement and analysis. There are eight types of elements, namely:

1. Repetitive
2. Occasional
3. Constant
4. Variable
5. Manual
6. Machine
7. Governing
8. Foreign

This division of jobs into elements is necessary to:

- provide better understanding of the nature of the job and to attract attention to the work method
- break up the time study exercise into parts which are of manageable size and which facilitate accurate study
- isolate machine elements from man elements

The nature of a job is variable and it may consist of:

- constant and variable time elements depending upon weight, size and so on
- manual and machine elements
- occasional or even foreign elements

Clear and well defined beginning and end points should be known to identify the elements. For the purpose of scientific study, it is necessary that:

- the elements are unified and consist of a logical sequence of basic motions
- the elements are short as possible so that these can be proper timed by some instruments
• regular and irregular elements are separate so that necessary time allowances to cover these tasks can be provided. Similarly, elements involving heavy and work leading to fatigue are separated for making proper allowances.
• constant and variable elements are separated for the purpose of generating necessary data in subsequent studies.
• the elements are timed to calculate the duration of the element.

10.4 Types of Elements

• **Repetitive**: These elements occur in every cycle of the given task or activity, e.g., loading and unloading.
• **Occasional**: These elements do not occur in every cycle of the task, but may occur at random or at regular intervals, e.g., breaking of threads in textile unit.
• **Constant**: These elements may or may not occur in every cycle, but they are identified in specification and time from cycle to cycle. For example, switching on and off of the machine, putting the cutting tool on the post and so forth.
• **Variable**: These are the elements where the time of performance varies with the characteristics of the products such as weight, size, etc., of the product. For example, loading and unloading of trunks.
• **Manual**: These are the elements performed by the worker.
• **Machine**: These are the elements which are automatically performed by machine, e.g., pressing, forging, etc.
• **Governing**: When two elements are present at the same time in a given cycle then that element which takes a longer time is called as governing elements. For example, boiling the kettle water while setting out tea pot and cups.
• **Foreign**: Those elements which are observed during the study but do not form the necessary part of the given activity of the cycle are known as foreign elements. For example, an operator stopping the machine when he wants to talk with his friend.

10.5 Benefits of Work Measurement

The work measurement technique is useful for:
• developing a basis for comparing the alternative methods developed by the method study by establishing the work content in each method of doing the job.
• correcting the manpower requirements for different tasks in a plant so that can be determined accurately by work measurement study.
• preparing accurate work schedules by assessing human work.
• planning and scheduling to meet delivery dates.
• setting standards of performance for labour for each element of work under ideal conditions.
• estimating production costs accurately.
• comparing the time taken by the worker with the standard time to maintain effective control of labour.
• accurately assessing the labour costs.
• providing the basic information to take decisions relating to the selling price, and for a filling up the tenders.
• developing new and more efficient methods.
• providing a rational basis for evolving incentive schemes.
• identifying the slow and standard workers for sending them for the training or treating them for their sickness.
• training the new employees for specific elements of jobs.
• checking progress of workers and taking necessary steps if required.
10.6 Techniques of Work Measurement

There are several techniques of work measurement developed by the experts. The commonly used techniques are discussed below:

10.6.1 Time Study

Time study is defined as a technique for determining as accurately as possible, the time required to carry out a specified task by a qualified worker at a defined level of performance.

It is a widely used technique of work measurement and is carried out when work is being done through direct observations. It aims at recording the time required to perform the task during a cycle and the rate at which the operator is working under specified conditions. This method has been criticised as being subjective and a biased one and also time consuming. Once the values are estimated they cannot be changed unless work content of the job and job conditions changes.

The main objectives of time study are to:

- provide the basis of comparing the operating effectiveness
- establish labour standards for satisfactory performance
- select the best method by comparing alternative methods
- determine the standard costs equipments, labour and so on
- determine normal times
- estimate number of machines an operator can handle efficiently
- provide the base for fixing piece rate or incentive wages
- determine the cycle time for completion of a job

Steps involved in the time study method

In order to carry out work measurement studies, it is necessary that the method studies are complete so that methods can be standardised. The time study has to be undertaken when the worker is performing the job according to the standardised method.

- **Selection of worker:** This is done in consultation with the foreman or union leader to suggest an operator who is skilled and steady person, so that his rate of performance is normal or near normal i.e. the observed time will be near to the normal time.

- **Collecting the identification details:** These include name of the part, its number, speed machinery used, name of the operator and observer etc.

- **Name of work:** It include the nature of raw materials used, size and shape of the job etc.

- **Work environment:** It includes temperature, ventilation, noise, smoke, vibrations, dust, etc.

- **Division of task into elements:** As the job is completed through a series of processes, it is usually divided into several parts or elements. This process is known as “Job breakdown”

- **Measuring the duration of each element:** The time study is conducted by observing time required to carry out each element of the job with the help of a stop watch.

- **Under the cumulative methods:** “timings are noted on continuous basis and time required for each element is recorded. In case of “Fly back Method”, time required for each element of work can be noted directly as each observation starts from a zero reading.

- **Performance rating:** All the operators do not work at the same pace as some work at a faster rate while others work at slower rates. Hence, while establishing the time standard for the work performance, some speed allowance has to be made in the time values obtained through time study. The determination of relative speed at which an operator is working is called as “rating”. Rating the speed of the operator is a matter of subjective judgment of a time study analyst. In order to avoid bias in rating, various techniques have been developed such as wasting house rating, 100% rating, etc.
**Determination of ‘representative time’ for each element:** The time taken by a operator to perform the same element of a job is never constant. This is because of variations in materials, equipments, pace of performance, etc. Hence using standardised raw materials, better quality equipments, better working conditions, etc., is recommended.

**Converting observed time for obtaining the ‘normal time’:** The representative time is based upon the observation of time taken by the operator to carryout each element of the job, while working at a certain pace or rate. As this pace is not normal it is necessary to convert the observed time into normal or basic time by multiplying observed time by rating factor.

Thus, Normal or Basic Time = Observed Time x Rating Factor (in %).

This can be explained with the following example:

Suppose the average observed time for an element is 0.15 minute and the rating factor is 90%.

The Basic time = (0.15 x 90)/100 = 0.135 minute

The operator has taken more time because he is a slow worker having rating factor at 90% which is less than the standard rating of 100%.

If the operator had been a fast worker, his rating would have been say 120%, and then the time expected from a standard rating would be 0.15x120/100 = 0.180 minutes.

**Calculation of standard time of the job:** Standard time is the total time in which a job should be completed at standard performance, i.e., standard time = basic time + allowances.

**Assessment of relaxation and other allowances:** When basic or normal times of the various elements of the job are added together, we get the normal or basic time for the job as a whole. But it may not be equal to the standard time, because of the lack of continuous work by employees. Some extra time has to be added to the normal time to estimate the standard time. Allowances have to be made for the normal work due to interruption, fatigue, personal needs etc. Such allowances are:

- **Process allowance:** It is an allowance in time given to compensate for an enforced idleness of the operator on account of peculiar character of process or operation that he is employed for.
  
  For example an operator may have to wait for a machine to complete its own part of the life cycle, or, he may be a member of an unbalanced team, or, he may be in charge of several machines some of which are periodically idle and he may not be able to attend to all of them at the same time. In such cases, there is a loss of production for which he is not responsible. Hence he must be covered against such losses. It is also called as ‘unavoidable delay allowance”. Generally 5% of the basic time is considered as a process allowance.

- **Relaxation allowance:** It is an addition to the basic time to provide the workers with an opportunity to recover for physiological and psychological effects of expending energy in the performance of a particular work under specified conditions and to allow for attendance to personal needs. This is also known as “Rest allowance” or “Fatigue allowance”. Relaxation allowance is given as 3% of the basic time.

- **Special allowances:** These are the allowances that are given for activities not forming part of the operation cycle but are essential for satisfactory performance of the work.

Such allowances may be permanent or temporary and are classified as follows:

- **Periodic activity allowances:** These are the allowances for activities carried out at definite intervals or after completing certain number of cycles. For example, cleaning machines, resetting of machines, etc.

- **Interference allowances:** The machines may complete their working cycles at irregular intervals so some of the machines may remain idle due to non attendance of the operator who is busy with other machines. This allowance is given to compensate the loss of earnings on account of loss in production.

- **Contingency allowances:** An allowance of the order of 5% is given to cover irregular occurrences which may occur. These incidences may be costly to study or may be impossible to study.

- **Policy Allowance:** These allowances are given at the discretion of management in addition to other necessary allowances. There allowances are given to motivate the workers to improve their performance. When a standard time is added to policy allowance the new time is known as “Allowance time.”
10.6.2 The Synthesis Method

In some industries the work done is repetitive in nature and the products manufactured are in large numbers or in batches of different sizes at irregular intervals. Under such conditions, it is tedious to carry out time studies. It is here that the synthesis technique is used.

Synthesis method is adopted to estimate the time required for doing a job at a defined level of performance by totalling or synthesising the values of elemental times obtained from earlier time studies on other jobs having similar job elements or from standard data or synthetic data.

The standard data is a list of normal or basic values for different elements of jobs. It is prepared by including the timings of standard elements. As similar elements are present in several jobs there is no need to carryout time studies for them repeatedly. This is more economical to use. Once the job elements are listed from the catalogue of standard data time the values for each element can be obtained and adding these values. We get estimate of normal times which can be converted into standard time by adding allowances.

Advantages
- helps in reducing cost of time studies
- time values are reliable as they are based on standard data
- can be used to estimate labour cost for new jobs

10.6.3 Predetermined Motion Time Systems (PMTS)

The PMTS is a technique of setting basic times for doing basic human activities necessary for carrying out a job or task. This method is said to be an improvement over motion study as it not only studies motions but also attempts to set a measure of time taken by series of motions.

Under this method:
- work is broken down into various motions which are then arranged in correct sequence
- the rated time is entered against each motion from a set of tables compiled for various motions
- the sum gives the total time to perform work. all times are standardised at normal rating and allowances are added to them

For example, time values for reach, grasp, move, etc., are basic motions and are predetermined which can be assigned to these motions. Addition of these values gives total time required to perform the operation.

Advantages
- As time for each basic motion is predetermined, the estimation of standard time for a job or operation is economical and faster than the time study.
- It helps in carrying out a detailed analysis and achieving an improvement in the work methods.
- It does not interfere with routine work hence the resistance of the workers tends to be least.
- It is more effective and economical tool of work measurement.

Disadvantages
- Standards for all the activities of human beings may not be available.
- Its application is limited for non repetitive and office work.
- Intensive training is required to make use of this technique.

In spite of these limitations the PMTS is considered as the most ideal system to get accurate estimates, because, under it, careful analysis is carried out about all the motions involved to perform a given job.
10.6.4 Analytical Estimating
This was developed in 1940’s to study non-repetitive jobs. Under it, the elements are estimated and not timed. The time values are determined on the basis of the experience of the work study engineer when no synthetic or standard data are available. It calls for an experienced engineer having adequate knowledge about estimating motions study, time study and use of standard data.
The steps involved in this method of work measurement are:

- find the job details and working conditions
- divide the job into various elements
- select time values from the standard data catalogue
- estimate time values for the elements for which standard data is not available, on the basis of past knowledge and experience
- add these time values to get total basic or normal time (for 100% rating)
- add usual blanket relaxation allowances, say 10 to 20% of total basic time
- add other allowances if applicable to get standard time for the given job

Advantages
- possesses all the advantages of the synthesis method
- helps in planning and scheduling production
- helps to fix the labour rate for non repetitive jobs
- helps in improving labour control

Disadvantages
- The analytical estimating procedure depends upon the judgment of the work engineer, the time values, hence may not be accurate and reliable.

In spite of this limitation, analytical estimating technique is applied to jobs which are not repetitive or have long cycle times or have variable elements. It is mostly used for repair and maintenance work, large projects, office procedures, construction works and so on.

10.6.5 Work Sampling
Work sampling technique was developed by L.H.C. Tippet for British textile mills, but later on it has been applied to other industries too. It is also called as activity sampling or ratio delay technique of work measurement.

Work sampling is a technique of work measurement which takes samples of the work of employees randomly at periodic intervals to determine the production of total operations that is accounted for in one particular activity. According to British Standards Institute, it is a technique which a statistically competent number of instantaneous observations are taken, over a period of time, of a group of machines process or workers. Each observation records what is seen to happen and the percentage of observations recorded for a particular activity or delay is a measure of the percentage of time observed by the occurrence.

Thus, according to the work sampling technique, a large number of observations are taken at random intervals of time and the condition of each machine or the member of the group is working or not is carefully observed and the causes of delay or idleness are also recorded. The percentage of the day during which the worker is idle is the ratio of the number of idle tally marks to the total number of both idle and tally marks.

For example: let out of 20 random observations, there are 5 idle observations. Then the percentage of idle time is 5/20 x 100 = 25% and percentage of working time will be 75%. If the shift is of eight hours then it may be concluded that the workers or machine remains idle for two hours and actually works for six hours only.
Objectives
Work sampling techniques’ objectives are to:
• estimate the non working or idle time of an equipment machinery or employee
• estimate allowances for calculating standard times
• estimate the non working or idle time of and equipment machinery or employee
• estimate the percentage of utilization of groups of similar machines
• provide basis for indirect labour time standards
• determine the standard time for a repetitive operation

Steps in work sampling procedure
The following are the main steps involved in activity or work sampling:
• Planning this stage includes selection of the work to be studied and timed, the desired accuracy limit (E) and
  the confidence level.
• Pilot study: A pilot study has to be conducted before the main study is carried out in order to decide the value
  of proportion of the occurrence in percentage value (P) and to determine the minimum number of observations
  (N) from the formula:
  \[ N = \frac{(K/E)^2 P(100-P)}{E^2} \]
  Where,
  \( P \) value is given in percentage
  \( K \) = number of standard deviations for a given confidence levels of 68%, 95% and 99% respectively.
  \( E \) = standard error = \( k \sqrt{pq/n} \)
  Where,
  \( p \) and \( q \) are number of operation
  \( N \) = required number of observations
• Actual study: An actual of activity sampling study is carried out. A minimum number of observations (N) are
  conducted as per the value of N obtained by step 2. This gives the result for confidence level. After taking N
  observations, the mean value of P for a given K value is estimated. The standard error is determined by:
  \[ E = \pm k \sqrt{pq/n} \]
  After determining the standard error, the range of P is found out’ a:
  \[ P_{max} = (P + E) \]
  \[ P_{min} = (P - E) \]
• Establishing basic time: It is estimated by using equation,
  \[ BT = P \times T \text{ where } T = \text{total time and } P = \% \text{ of total time utilized for work.} \]
  Basic time will also have maximum and minimum limits depending upon maximum and minimum value of P
  respectively.
• Calculation of standard time (ST) by the equation:
  \[ ST = BT + A \]
  Where,
  \( A \) = Allowances

Example 1
A shop supervisor is interested in knowing the percentage of time his shop is idle. Estimate the minimum number
of observations necessary to give a 95% confidence level so that the results are accurate within + 5%.
A pilot study showed that 40 times out of 100 observations the shop was idle.

Solution
Given, \( P = 40/100 = 40\% \) and \( E = 5\% \)
K value at 95%, confidence level is 2
Minimum number of observations \( N = \frac{(K/E)^2 P(1 -P)}{(2/5)^2 \times 40 \times 60} = 384. \)
**Example 2**
In a work sampling study, a mechanic was found idle for 20% of the time. Find out the number of observations needed to confirm to the above figures with the confidence level of 95% and a relative error level by ± 5%.

**Solution**
No. of observations required \( N = C^2 \frac{PQ}{E^2} \)
Where,
\( C = \) constant depending upon confidence level = 2 for 95% confidence level
\( P = \) percentage of idling
\( Q = \) percentage of activity = 1 - P
\( E = \) absolute error = S x P, where S is relative error

Thus,
\[
N = \frac{4 \times 0.2 \times 0.8}{(0.05 \times 0.2)^2} = \frac{64}{0.0001} = 6400
\]
Summary

- Work measurement is mainly concerned with the determination of the total time required to perform a unit of work.
- Work measurement is defined as the techniques applied to determine the amount of time necessary for a qualified worker to perform a particular task.
- The eight types of elements of work measurement are repetitive, occasional, constant, variable, manual, machine, governing and foreign.
- Main objective of work measurement is to fix the standard time for each job scientifically, which helps to workout realistic schedules and manpower requirements.
- The prominent techniques of work measurement are Time Study, Synthesis Method, Predetermined Motion Time Systems (PMTS), Analytical Estimating and Work Sampling.
- Time study technique of work measurement widely used technique of work measurement and is carried out when work is being done through direct observations.
- Work sampling is a technique of work measurement which takes samples of the work of employees randomly at periodic intervals to determine the production of total operations that is accounted for in one particular activity.
- The PMTS is a technique of setting basic times for doing basic human activities necessary for carrying out a job or task.
- In analytical estimating, the time values are determined on the basis of the experience of the work study engineer when no synthetic or standard data are available.
- Synthesis is a technique of work measurement adopted to estimate the time required for doing a job at a defined level of performance by totalling the values of elemental times obtained from earlier time studies on other jobs having similar job elements.

Reference


Recommended Reading

Self Assessment

1. __________ may be defined as the techniques applied to determine the amount of time necessary for a qualified worker to perform a particular task.
   a. Work measurement
   b. Work analysis
   c. Work strategic
   d. Work management

2. ________ is a distinct part of a specified job selected for convenience by way of observation, measurement and analysis
   a. Event
   b. Element
   c. Component
   d. Module

3. ________ and _________ elements need to be separated so that necessary time allowances to cover these tasks can be provided.
   a. External, internal
   b. Explicit, implicit
   c. Regular, irregular
   d. Rational, irrational.

4. The __________ is a technique of setting basic times for doing basic human activities necessary for carrying out a job or task.
   a. PMS
   b. PMTR
   c. PMPT
   d. PMTS

5. Which elements are observed during the study but do not form the necessary part of the given activity of the cycle?
   a. foreign elements
   b. external elements
   c. internal elements
   d. rational elements

6. State which of the following statement is false.
   a. Work measurement is the techniques applied to determine the amount of time necessary for a qualified worker to perform a particular task.
   b. Repetitive elements do not occur in every cycle of the given task or activity.
   c. The time study has to be undertaken when the worker is performing the job according to the standardised method.
   d. The standard data is a list of normal or basic values for different elements of jobs.
7. Which of the following is characteristic of variable elements?
   a. Possible to measure
   b. Not possible to measure
   c. Predictable
   d. Time of performance varies with the characteristics of the products such as weight, size and so on.

8. Which of the following are the allowances for activities carried out at definite intervals or after completing certain number of cycles?
   a. Periodic activity allowances
   b. Relaxation allowance
   c. Special allowances
   d. Process allowance

9. Analytical estimating was developed in 1940’s to study which of following job?
   a. Repetitive
   b. Non-repetitive
   c. Sampling
   d. Scheduling

10. Who developed work sampling technique?
    a. L.H.C. Tippet
    b. John Thomas
    c. A. K. Thomas
    d. M. Fayol
MRC Bearings’ TPM Journey: From Totally Painted Machines to Taking Pride in our Machines

In 1996 MRC Bearings, a unionised aerospace industry supplier recognised it had a problem. They were behind on their orders. Their customers were pushing for shorter lead times and cost reductions.

Approximately 80% of their maintenance hours were dedicated to emergency work orders. In October of 1997, over one 1660 hours were consumed by unplanned maintenance in just one area. Ten months later that number fell to less than 30 hours, i.e., over a 99% decrease.

In another area, they were able to achieve almost a 98% decrease in the number of unplanned maintenance hours in an eight-month period.

Greg Folts, Manager of Continuous Improvement at MRC attributes their remarkable success to having a hardworking, dedicated maintenance team and implementing a Total Productive Maintenance (TPM) program.

MRC began with a week-long TPM event. Folts explained they would begin by cleaning, inspecting, lubricating and performing corrective work on a piece of machinery. Once a machine was cleaned, it would be painted. At first, people were reluctant to participate in TPM events. As time went on, people began to notice what improvements were being accomplished under the TPM events. “In fact, the same people that were hesitating in the beginning were suddenly asking when their machine would be scheduled for a TPM event,” Folts said. From this experience, Russell suggests organisations beginning TPM programs start small and keep it simple.

Questions

1. What is Total Productive Maintenance?

   Answer

   The TPM is an innovative approach of maintenance developed by Japanese manufacturers. Total Productive Maintenance provides the methods to measure and eliminate much of the non-productive time, if implemented properly. TPM is a maintenance process developed for improving productivity by making processes more reliable and less wasteful.

2. What are the objectives of TPM?

   Answer

   The main objective of the TPM is to develop an operational system which is “maintenance free”. The other objectives of TPM are:

   - zero accidents
   - no unplanned downtime
   - minimum life cycle
   - zero speed losses
   - zero defects
3. What are the benefits of TPM to any organisation?

**Answer**

Benefits of TPM are:

- involvement of entire staff in support functions for focusing on better plant performance
- better utilisation work area
- reduction in repetitive work
- minimisation in inventory levels in all parts of the supply chain
- lessened administrative costs
- reduction in inventory carrying cost
- reduction in number of files
- decrease in overhead costs (to include cost of non-production/non capital equipment)
- productivity of people in support functions
- reduction in breakdown of office equipment
- less customer complaints due to logistics
- reduction in expenses due to emergency dispatches/purchases
- reduced manpower
- clean and pleasant work environment
Case Study II

MRP System Implementation in a Medium-sized Food Processing Factory

This case study describes a Material Requirements Planning (MRP) system implementation undertaken at a medium sized food processing factory, by migrating from paper based and disparate to stand-alone electronic systems. Whilst the company had managed, on a smaller scale, to satisfy theirs and their customer needs they had since outgrown the core capabilities of the business namely, SOP, production, supply management and accounting.

The firm had arrived at a point where their customer and supplier dissatisfaction had reached a critical level and needed to stemmed and reversed. Customers were not getting what they ordered, suppliers were not being paid and actions were needed. At the directions of the Board, a feasibility study was undertaken on the implementation of an integrated MRP System and the findings were accepted by the board.

The scope included a complete overhaul of all existing systems and the specification, development and implementation of a totally new IT infrastructure.

At the same time, over one hundred employees, of which the vast majority had no experience with IT, needed to be convinced that the changes were beneficial to them and the company’s future. Aside from hearts and minds, a thorough training programme was needed to be devised and undertaken.

As the process affected were mission critical, it was essential to structure the project in an efficient manner to identify and minimise any risks and ensure all critical processes were functional from the inception. The company has significantly improved efficiency traceability and the ability for future expansion.

Key areas of improvement for the company were as follows;
- A new IT Infrastructure comprising the most up to date technology.
- An integrated system that brought all the standalone systems together providing a rapid overview of the financial aspects of the company as well as much improved supply management and works in progress management.
- Customer relationship management allowed the managers to contact their customer; and access all their contact history to enable informed sales and service’ levels.
- Automation of many document functions including invoking, despatch and delivery note generation, driver instructions and work orders.

Questions
1. What is MRP?
2. Why was it necessary to implement MRP system in the factory?
3. What were the areas of improvement for the company after implementing MRP?
4. Why is MRP system implemented in a company?
5. How will you convince the employees about benefits of MRP system?
Case Study III

Just-in-Time JIT

May 2004, Toyota Motor Corporation (Toyota) announced record financial results for the fiscal year ended March 2004. The company’s revenues and operating income had reached highs of $163 billion and $15 billion respectively. What was noteworthy, however, was that the company’s net earnings were more than double the combined net earnings of automobile majors General Motors (GM), Ford, DaimlerChrysler and Honda for their latest fiscals. Toyota was firmly entrenched as the most profitable company in the automobile industry in the early 2000s. At a time when the giants of the industry were making meagre profits and some were even suffering losses, it showed steady profits.

This profitability gave the company a strong position in the Japanese economy as well as in the global automobile industry, and helped it grow rapidly.

Because of its stable cash position, it was able to invest in the development of new technologies like hybrid engine systems and develop brands like the youth-focused ‘Scion’, which many believed to be risky. Analysts said that the foundation of Toyota’s strong performance was its much analysed and emulated manufacturing system, which made use of concepts like Just-in-Time (JIT) and Kaizen or the process of continuous improvement, to reach a high level of efficiency in production. Through its competitive advantage in manufacturing, Toyota was not only able to maintain its award winning levels of quality, but was also able to rapidly capture market share by exercising aggressive cost control and churning out better car models.

Questions

1. What is JIT?
2. What are the objectives of JIT?
3. How was JIT beneficial for Toyota Motor Corporation?
4. According to analysts, what was the foundation of Toyota’s strong performance in the market?
Bibliography

References

- Methods of Production

Recommended Reading


• Verghese B.V., Kumar, N. Production Management, Anmol Publications Pvt. Ltd. 396 pages.
Self Assessment Answers

Chapter I
1. a
2. b
3. c
4. d
5. a
6. b
7. c
8. d
9. b
10. b

Chapter II
1. c
2. b
3. a
4. b
5. a
6. c
7. a
8. b
9. c
10. a

Chapter III
1. a
2. b
3. c
4. d
5. b
6. a
7. b
8. d
9. d
10. a

Chapter IV
1. a
2. b
3. b
4. b
5. a
6. d
7. b
8. a
9. a
10. d
Chapter V
1. a
2. b
3. c
4. d
5. a
6. b
7. a
8. d
9. a
10. a

Chapter VI
1. a
2. b
3. c
4. d
5. a
6. b
7. c
8. d
9. a
10. b

Chapter VII
1. a
2. b
3. c
4. d
5. a
6. b
7. c
8. d
9. a
10. b

Chapter VIII
1. a
2. b
3. c
4. d
5. a
6. b
7. b
8. c
9. d
10. a
Chapter IX
1. a
2. b
3. c
4. d
5. a
6. b
7. c
8. d
9. b
10. a

Chapter X
1. a
2. b
3. c
4. d
5. a
6. b
7. d
8. a
9. b
10. a