DEFINE : PRODUCTIVITY

Productivity is the quantitative relation between what we produce and we use as a resource to produce them, i.e., arithmetic ratio of amount produced (output) to the amount of resources (input). Productivity can be expressed as:

Productivity =Output/ Input

Productivity refers to the efficiency of the production system. It is the concept that guides the management of production system. It is an indicator to how well the factors of production (land, capital, labor and energy) are utilized.

European Productivity Agency (EPA) has defined productivity as, "Productivity is an attitude of mind. It is the mentality of progress, of the constant improvements of that which exists. It is the certainty of being able to do better today than yesterday and continuously. It is the constant adaptation of economic and social life to changing conditions. It is the continual effort to apply new techniques and methods. It is the faith in progress."

A major problem with productivity is that it means many things to many people. Economists determine it from Gross National Product (GNP), managers view it as cost cutting and speed up, engineers think of it in terms of more output per hour. But generally accepted meaning is that it is the relationship between goods and services produced and the resources employed in their production.

Factors Influencing Productivity

Factors influencing productivity can be classified broadly into two categories:

A. controllable (or internal) factors and
B. un-controllable (or external) factors.

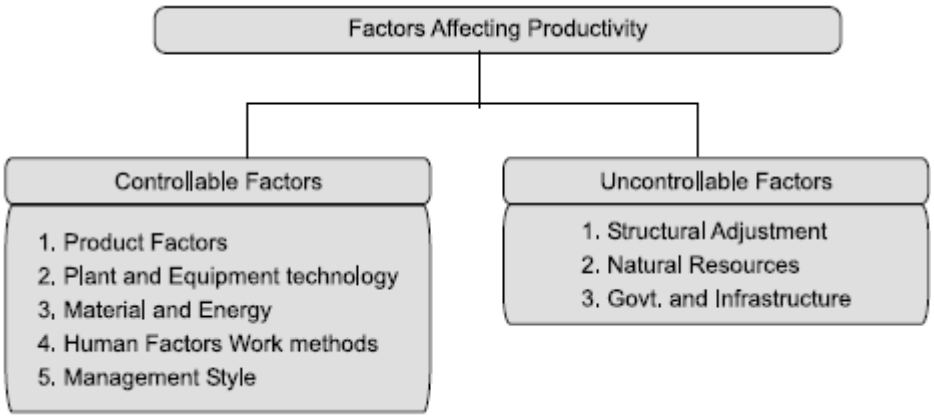
A. CONTROLLABLE FOR INTERNAL FACTORS

1. **Product factor:** In terms of productivity means the extent to which the product meets output requirements product is judged by its usefulness. The cost benefit factor of a

product can be enhanced by increasing the benefit at the same cost or by reducing cost for the same benefit.

2. **Plant and equipment:** These play a prominent role in enhancing the productivity. The increased availability of the plant through proper maintenance and reduction of idle time increases the productivity. Productivity can be increased by paying proper attention to utilization, age, modernization, cost, investments etc.

Factors influencing productivity



3. **Technology:** Innovative and latest technology improves productivity to a greater extent. Automation and information technology helps to achieve improvements in material handling, storage, communication system and quality control. The various aspects of technology factors to be considered are:

i. Size and capacity of the plant,
ii. Timely supply and quality of inputs,
iii. Production planning and control,
iv. Repairs and maintenance,
v. Waste reduction, and
vi. Efficient material handling system.

4. **Material and energy:**

Efforts to reduce materials and energy consumption brings about considerable improvement in productivity.

1. Selection of quality material and right material.

2. Control of wastage and scrap.
3. Effective stock control.
4. Development of sources of supply.
5. Optimum energy utilization and energy savings.
6. **Human factors**

Productivity is basically dependent upon human competence and skill. Ability to work effectively is governed by various factors such as education, training, experience aptitude etc., of the employees. Motivation of employees will influence productivity.

7. **Work methods:** Improving the ways in which the work is done (methods) improves productivity, work study and industrial engineering techniques and training are the areas which improve the work methods, which in term enhance the productivity.
8. **Management style:** This influence the organizational design, communication in organization, policy and procedures. A flexible and dynamic management style is a better approach to achieve higher productivity.

UNCONTROLLABLE (OR) EXTERNAL FACTORS

Structural adjustments: Structural adjustments include both economic and social changes. Economic changes that influence significantly are:

. Shift in employment from agriculture to manufacturing industry,

a. Import of technology, and
b. Industrial competitiveness.

Social changes such as women's participation in the labor force, education, cultural values, attitudes are some of the factors that play a significant role in the improvement of productivity.

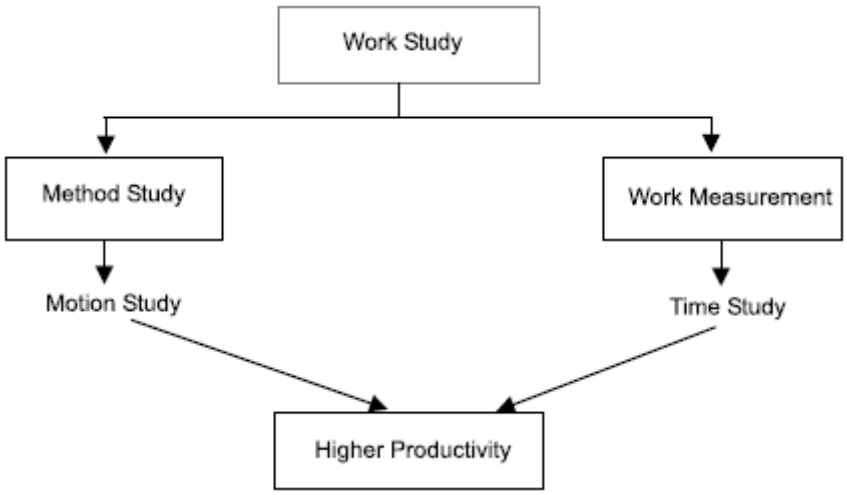
Natural resources: Manpower, land and raw materials are vital to the productivity improvement.

Government and infrastructure: Government policies and program are significant to productivity practices of government agencies, transport and communication power, fiscal policies (interest rates, taxes) influence productivity to the greater extent.

CHAPTER-2 WORK STUDY

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

Framework of work study



Work Study in Management Science

Work study is a means of enhancing the production efficiency (productivity) of the firm by elimination of waste and unnecessary operations. It is a technique to identify non-value adding operations by investigation of all the factors affecting the job. It is the only accurate and systematic procedure oriented technique to establish time standards. It is going to contribute to the profit as the savings will start immediately and continue throughout the life of the product. Method study and work measurement is part of work study. Part of method study is motion study, work measurement is also called by the name 'Time study'.

Advantages of Work Study

Following are the advantages of work study:

1. It helps to achieve the smooth production flow with minimum interruptions.
2. It helps to reduce the cost of the product by eliminating waste and unnecessary operations.
3. Better worker-management relations.
4. Meets the delivery commitment.
5. Reduction in rejections and scrap and higher utilization of resources of the organization.
6. Helps to achieve better working conditions.
7. Better workplace layout.
8. Improves upon the existing process or methods and helps in standardization and simplification.
9. Helps to establish the standard time for an operation or job which has got application in manpower planning, production planning.

CHAPTER-3 METHOD STUDY

METHOD STUDY

The basic approach suggested for the method study consists of eight steps.

1. SELECT

2. RECORD

3. EXAMINE

4. DEVELOP

5. EVALUATE

6. DEFINE

7. INSTALL

8. MAINTAIN

Brief explanation of the eight steps

1. SELECT

The process to be studied to selected and its boundaries are to be defined

2. RECORD

The process is to be recorded in specified charts and diagrams.

Process charts
Flow charts
Flow diagram
String diagram

A variety of techniques for analysis and charting have for a long time been established as IE techniques. Among the methods of analysis, process analysis, operation analysis, motion study, time study, work sampling, and flow analysis are widely used. Similarly, among the charting techniques, process charts, pitch diagrams, multiple activity charts, process charts, and machine sequential charts are used. From among these various techniques, the appropriate one will be chosen, based on the object being analyzed [3].

Process charts were used and advocated by Frank Gilbreth in a paper presented to ASME in 1921.

3. EXAMINE

A process or method has activities.
The activities are categorized into action activities and idle (inventory) activities.
Action categories are subdivided into i) MAKE READY activities, (ii) Do operations iii) PUT AWAY activities

Each activity is subjected to a series of questions:

A. Purpose

What is done?

Why is it done?

What else might be done?

What should be done?

B. Place

Where is it done?

Why is it done there?

Where else might it be done?

Where should it be done?

C. Sequence

When is it done?

Why is done then?

When it might be done?

When should it be done?

D. Person

Who does it?

Why does that person do it?

Who else might do it?

Who should do it?

E. Means

How is it done?

Why is it done that way?

How else might it be done?

How should it be done?

These questions in the above sequence must be asked every time a method study is undertaken. They are the basis of successful method study.

4. DEVELOP

The shortcomings of the present process are brought out by the systematic questioning process that is combined with a knowledge relevant to the process being examined. Industrial may have the knowledge required or may not have the adequate knowledge. They need to have a knowledge library to support their effort as well as access to the experts during the study period. Alternatives to the current activities which have the shortcomings are to be generated during this stage.

5. EVALUATE

Alternatives are to be evaluated at this stage to find their contribution to the efficiency of the process as well as effectiveness.

6. DEFINE

The new method or process suggested has to be put down standard process sheets that are issued to the shop or department.

7. INSTALL

Industrial engineers of methods study persons have to train the operators and their supervisors in the new method and participate in installing the method.

8. MAINTAIN

Industrial engineers have to conduct a periodic review of methods to observe modifications brought into the installed methods by operators and supervisors and if they are beneficial, they have to be made part of standard operating procedure (SOP). If they are not beneficial, supervisors are to be informed of the same to bring the method back to SOP.

Method study enables the industrial engineer to subject each operation to systematic analysis. The main purpose of method study is to eliminate the unnecessary operations and to achieve the best method of performing the operation. Method study is also called **methods engineering or work design.**

Method engineering is used to describe collection of analysis techniques which focus on improving the effectiveness of men and machines. According to British Standards Institution (BS 3138): "Method study is the systematic recording and critical examination or existing and proposed ways or doing work as a means or developing and applying easier and more effective methods and reducing cost."

Fundamentally method study involves the breakdown of an operation or procedure into its component elements and their systematic analysis. In carrying out the method study, the right attitude of mind is important. The method study man should have:

1. The desire and determination to produce results.
2. Ability to achieve results.
3. An understanding of the human factors involved.

Method study scope lies in improving work methods through process and operation analysis, such as:

1. Manufacturing operations and their sequence.
2. Workmen.
3. Materials, tools and gauges.
4. Layout of physical facilities and work station design.
5. Movement of men and material handling.
6. Work environment.

Objectives of Method Study

Method study is essentially concerned with finding better ways of doing things. It adds value and increases the efficiency by eliminating unnecessary operations, avoidable delays and other forms of waste. The improvement in efficiency is achieved through:

1. Improved layout and design of workplace.
2. Improved and efficient work procedures.
3. Effective utilization of men, machines and materials.
4. Improved design or specification of the final product.

The objectives of method study techniques are:

1. Present and analyze true facts concerning the situation.
2. To examine those facts critically.
3. To develop the best answer possible under given circumstances based on critical examination of facts.

Scope of Method Study

The scope of method study is not restricted to only manufacturing industries. Method study techniques can be applied effectively in service sector as well. It can be applied in offices, hospitals, banks and other service organizations. The areas to which method study can be applied successfully in manufacturing are:

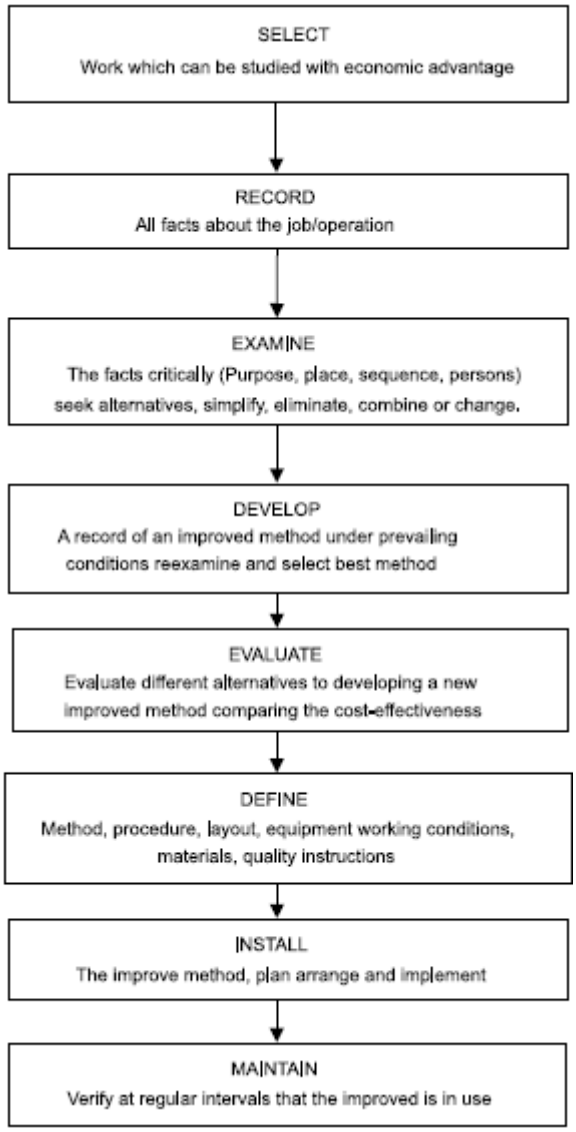
1. To improve work methods and procedures.
2. To determine the best sequence of doing work.
3. To smoothen material flow with minimum of back tracking and to improve layout.
4. To improve the working conditions and hence to improve labor efficiency.
5. To reduce monotony in the work.
6. To improve plant utilization and material utilization.
7. Elimination of waste and unproductive operations.
8. To reduce the manufacturing costs through reducing cycle time of operations.

Steps or Procedure Involved in Methods Study

The basic approach to method study consists of the following eight steps. The detailed procedure for conducting the method study is shown in the following figure.

1. **SELECT** the work to be studied and define its boundaries.
2. **RECORD** the relevant facts about the job by direct observation and collect such additional data as may be needed from appropriate sources.
3. **EXAMINE** the way the job is being performed and challenge its purpose, place sequence and method of performance.

Method study procedure



4. **DEVELOP** the most practical, economic and effective method, drawing on the contributions of those concerned.
5. **EVALUATE** different alternatives to developing a new improved method comparing the cost- effectiveness of the selected new method with the current method with the current method of performance.
6. **DEFINE** the new method, as a result, in a clear manner and present it to those concerned, i.e., management, supervisors and workers.
7. **INSTALL** the new method as a standard practice and train the persons involved in applying it.
8. **MAINTAIN** the new method and introduce control procedures to prevent a drifting back to the previous method of work.

Note:

Only the first two steps have been dealt in detail.

Selection of the Job for Method Study

Cost is the main criteria for selection of a job, process and department for methods analysis. To carry out the method study, a job is selected such that the proposed method achieves one or more of the following results:

a. Improvement in quality with lesser scrap.
b. Increased production through better utilization of resources.
c. Elimination of unnecessary operations and movements.
d. Improved layout leading to smooth flow of material and a balanced production line.
e. Improved working conditions.

CONSIDERATIONS FOR SELECTION OF METHOD STUDY

The job should be selected for the method study based upon the following considerations:

1. Economic aspect
2. Technical aspect, and
3. Human aspect.

A. **Economic Aspects**

The method study involves cost and time. If sufficient returns are not attained, the whole exercise will go waste. Thus, the money spent should be justified by the savings from it. The following guidelines can be used for selecting a job:

a. Bottleneck operations which are holding up other production operations.
b. Operations involving excessive labor.
c. Operations producing lot of scrap or defectives.
d. Operations having poor utilization of resources.
e. Backtracking of materials and excessive movement of materials.

B. **Technical Aspects**

The method study man should be careful enough to select a job in which he has the technical knowledge and expertise. A person selecting a job in his area of expertise is going to do full justice.

Other factors which favor selection in technical aspect are:

1. Job having in consistent quality.
2. Operations generating lot of scraps.
3. Frequent complaints from workers regarding the job.

Human Considerations

Method study means a change as it is going to affect the way in which the job is done presently and is not fully accepted by workman and the union. Human considerations play a vital role in method study. These are some of the situations where human aspect should be given due importance:

a. Workers complaining about unnecessary and tiring work.
b. More frequency of accidents.
c. Inconsistent earning.

Recording Techniques for Method Study

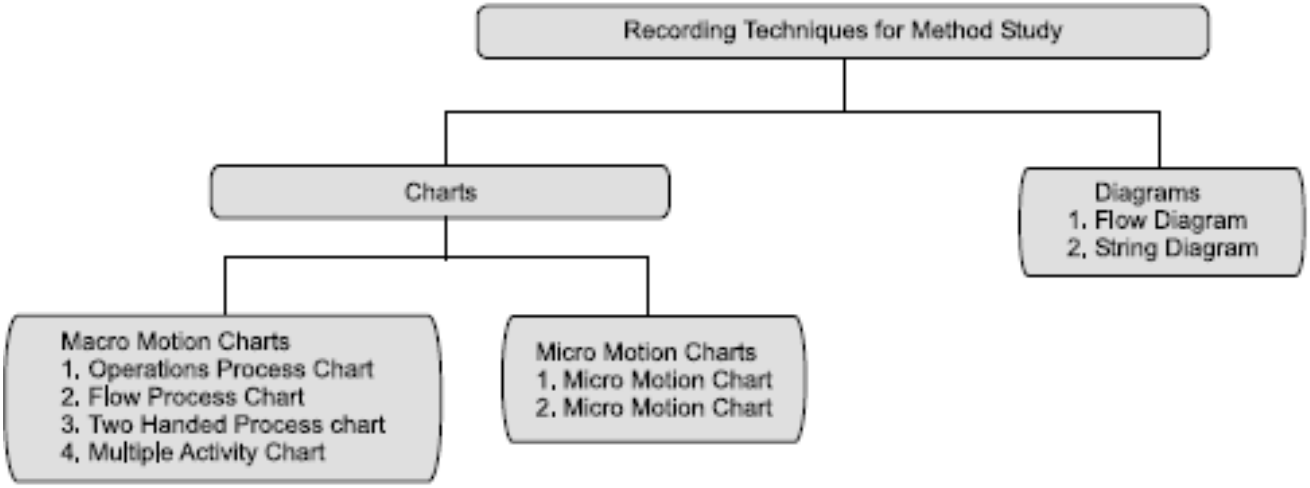
The next step in basic procedure, after selecting the work to be studied is to record all facts relating to the existing method. In order that the activities selected for investigation may be visualized in their entirety and in order to improve them through subsequent critical examination, it is essential to have some means of placing on record all the necessary facts about the existing method. Records are very much useful to make before and after comparison to assess the effectiveness of the proposed improved method.

The recording techniques are designed to simplify and standardize the recording work. For this purpose charts and diagrams are used.

Method Study techniques

The method study techniques are explained below

Recording techniques for method study



CHARTS USED IN METHODS STUDY

This is the most popular method of recording the facts. The activities comprising the jobs are recorded using method study symbols. A great care is to be taken in preparing the charts so that the information it shows is easily understood and recognized. The following information should be given in the chart. These charts are used to measure the movement of operator or work (i.e., in motion study).

a. Adequate description of the activities.
b. Whether the charting is for present or proposed method.
c. Specific reference to when the activities will begin and end.
d. Time and distance scales used wherever necessary.
e. The date of charting and the name of the person who does charting.

Types of Charts

It can be broadly divided into (A) Macro motion charts and (B) Micro motion charts. Macro motion charts are used for macro motion study and micro motion charts are used for micro motion study. Macro motion study is one which can be measured through ‘stop watch’ and micro motion study is one which cannot be measured through stop watch.

MACRO MOTION CHARTS

Following four charts are used under this type:

1. **Operation Process Chart**

It is also called outline process chart. An operation process chart gives the bird's eye view of the whole process by recording only the major activities and inspections involved in the process. Operation process chart uses only two symbols, i.e., operation and inspection. Operation, process chart is helpful to:

a. Visualize the complete sequence of the operations and inspections in the process.
b. Know where the operation selected for detailed study fits into the entire process.
c. In operation process chart, the graphic representation of the points at which materials are introduced into the process and what operations and inspections are carried

2. **Flow Process Chart**

Flow process chart gives the sequence of flow of work of a product or any part of it through the work centre or the department recording the events using appropriate symbols. It is the amplification of the operation process chart in which operations; inspection, storage, delay and transportation are represented. However, process charts are of three types:

a. Material type— which shows the events that occur to the materials.
b. Man type—Activities performed by the man.
c. Equipment type— how equipment is used.

The flow process chart is useful:

d. to reduce the distance travelled by men (or materials).
e. to avoid waiting time and unnecessary delays.
f. to reduce the cycle time by combining or eliminating operations.
g. to fix up the sequence of operations.
h. to relocate the inspection stages.

Like operation process chart, flow process chart is constructed by placing symbols one below another as per the occurrence of the activities and are joined by a vertical line. A brief description of the activity is written on the right hand side of the activity symbol and time or distance is given on the left hand side.

3. **Two Handed Process Chart**

   A two handed (operator process chart) is the most detailed type of flow chart in which the activities of the workers hands are recorded in relation to one another. The two handed process chart is normally confined to work carried out at a single workplace. This also gives synchronized and graphical representation of the sequence of manual activities of the worker. The application of this charts are:

- To visualize the complete sequence of activities in a repetitive task.
- To study the work station layout.

Multiple Activity Chart

It is a chart where activities of more than subject (worker or equipment) are each recorded on a common time scale to show their inter-relationship. Multiple activity chart is made:

- to study idle time of the man and machines,
- to determine number of machines handled by one operator, and
- to determine number of operators required in teamwork to perform the given job.

Diagrams Used in Method Study

The flow process chart shows the sequence and nature of movement but it does not clearly show the path of movements. In the paths of movements, there are often undesirable features such as congestion, back tracking and unnecessary long movements. To record these unnecessary features, representation of the working area in the form of flow diagrams, string diagrams can be made:

1. To study the different layout plans and thereby; select the most optimal layout.
2. To study traffic and frequency over different routes of the plant.
3. Identification of back tracking and obstacles during movements.

Diagrams are of two types:

1. Flow diagram and
2. String diagram.

1. FLOW DIAGRAM

Flow diagram is a drawing, of the working area, showing the location of the various activities identified by their numbered symbols and are associated with particular flow process chart either man type or machine type.The routes followed in transport are shown by joining the symbols in sequence by a line which represents as nearly as possible the path or movement of the subject concerned. Following are the procedures to make the flow diagram:

1. The layout of the workplace is drawn to scale.
2. Relative positions of the machine tools, work benches, storage, and inspection benches are marked on the scale.
3. Path followed by the subject under study is tracked by drawing lines.
4. Each movement is serially numbered and indicated by arrow for direction.
5. Different colors are used to denote different types of movements.

2. STRING DIAGRAM

The string diagram is a scale layout drawing on which, length of a string is used to record the extent as well as the pattern of movement of a worker working within a limited area during a certain period of time. The primary function of a string diagram is to produce a record of a existing set of conditions so that the job of seeing what is actually taking place is made as simple as possible.

One of the most valuable features of the string diagram is the actual distance travelled during the period of study to be calculated by relating the length of the thread used to the scale of drawing. Thus, it helps to make a very effective comparison between different layouts or methods of doing job in terms of the travelling involved. The main advantages of string diagram compared to flow diagram is that respective movements between work stations which are difficult to be traced on the flow diagram can be conveniently shown on string diagram.

Following are the procedures to draw string diagram:

1. A layout of the work place of factory is drawn to scale on the soft board.
2. Pins are fixed into boards to mark the locations of work stations, pins are also driven at the turning points of the routes.
3. A measured length of the thread is taken to trace the movements (path).
4. The distance covered by the object is obtained by measuring the remaining part of the thread and subtracting it from original length.

Symbols Used in Method Study

Graphical method of recording was originated by Gilberth, in order to make the presentation of the facts clearly without any ambiguity and to enable to grasp them quickly and clearly. It is useful to use symbols instead of written description.

METHOD STUDY SYMBOLS

O OPERATION
□ INSPECTION
→ TRANSPORTATION
D DELAY
∇ STORAGE

Operation

An operation occurs when an object is intentionally changed in one or more of its characteristics (physical or chemical). This indicates the main steps in a process, method or procedure.

An operation always takes the object one stage ahead towards completion. Examples of operation are:

- Turning, drilling, milling, etc.
- A chemical reaction.
- Welding, brazing and riveting.
- Lifting, loading, unloading.
- Getting instructions from supervisor.

Inspection

An inspection occurs when an object is examined and compared with standard for quality and quantity. The inspection examples are:

- Visual observations for finish.
- Count of quantity of incoming material.
- Checking the dimensions.

Transportation

A transport indicates the movement of workers, materials or equipment from one place to another.

Example:

Movement of materials from one work station to another. Workers travelling to bring tools.

Delay D: Delay (Temporary Storage)

A delay occurs when the immediate performance of the next planned thing does not take place.

Example:

- Work waiting between consecutive operations.
- Workers waiting at tool cribs.
- Operators waiting for instructions from supervisor.

Storage

Storage occurs when the object is kept in an authorized custody and is protected against unauthorized removal. For example, materials kept in stores to be distributed to various work.

ILLUSTRATION 1. Develop a Process Chart for making a cheese sandwich.

SOLUTION. The following chart is one possible solution. The level of detail in process charts depends upon the requirements of the job. Time is often included to aid analysis of value added.

Process Chart

Distance in Symbol Process description meter

Distance in metre	*Symbol*	*Process description*
10	⇨	Move to cabinet
-	○	Get loaf of bread
-	○	Remove two slices of bread
-	○	Lay slices on counter-top
-	○	Close loaf of bread
	○	Replace loaf of bread on shelf
-	○	Open butter
-	○	Spread butter on top slice of bread
-	□	Inspect sandwich
10	⇨	Move to serving area
-	○	Serve sandwich

ILLUSTRATION 2

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Develop a Multiple Activity Chart for doing three loads of laundry, assume you will have access to one washing machine and one dryer.

SOLUTION:

The following chart is one possible solution. The level of detail in process charts depends upon the requirements of the job. Time is often included to aid analysis of value added.

Time	*Operator*	*Machine 1 Washer*	*Machine 2 Dryer*
	Load clothes and detergent in to Machine 1	Being loaded	Idle
	Idle	Run	Idle
	Remove clothes from Machine 1	Being unloaded	Idle
Repeat	Load clothes into Machine 2	Idle	Being loaded
Cycle	Load clothes and detergent into Machine 1	Being loaded	Run
	Idle	Run	Run
	Remove clothes from Machine 2	Idle	Being unloaded
	Hang clothes	Idle	Idle

MICRO-MOTION STUDY CHART

Micro-motion study provides a technique for recording and timing an activity. It is a set of techniques intended to divide the human activities in a groups of movements or micro-motions (called Therbligs) and the study of such movements helps to find for an operator one best pattern of movements that consumes less time and requires less effort to accomplish the task. Therbligs were suggested by Frank O. Gilbreth, the founder of motion study. Micro-motion study was mainly employed for the job analysis. Its other applications include:

1. As an aid in studying the activities of two or more persons on a group work?
2. As an aid in studying the relationship of the activities of the operator and the machine as a means of timing operations.
3. As an aid in obtaining motion time data for time standards.
4. Acts as permanent record of the method and time of activities of the operator and the machine.

SIMO chart symbols

Sl. No.	*Code*	*Name*	*Description*	*Colour*
1.	SH	SEARCH	Locate and article	Black
2.	F	FIND	Mental reaction at end of search	Gray
3.	ST	SELECT	Selection from a member	Light Gray
4.	G	GRASP	Taking Hold	Red
5.	H	HOLD	Prolonged group	Gold Ochre
6.	TL	TRANSPORTED LOADED	Moving an article	Green
7.	P	POSITION	Placing in a definite location	Blue
8.	A	ASSEMBLE	Putting parts together	Violet
9.	U	USE	Causing a device to perform its function	Purple
10.	DA	DISASSEMBLE	Separating parts	Light Violet
11.	I	INSPECT	Examine or test	Burnt Ochre
12.	PP	PREPOSITION	Placing an article ready for use	Pale Blue
13.	RL	RELEASE LOAD	Release an article	Carmine red
14.	TE	TRANSPORT EMPTY	Movement of a body member	Olive Green
15.	R	REST	Pause to overcome fatigue	Orange
16.	JD	UNAVOIDABLE DELAY	Idle-outside persons control	Yellow
17.	PN	PLAN	Mental plan for future action	—

The micro-motion group of techniques is based on the idea of dividing human activities into division of movements or groups of movements (Therbligs) according to purpose for which they are made. Gilbreth differentiated 17 fundamental hand or hand and eye motions. Each Therbligs has a specific color, symbol and letter for recording purposes. The Therbligs are micro-motion study involves the following steps:

1. Filming the operation to be studied.
2. Analysis of the data from the film.

The recording of the data through **SIMO chart** is done as micro motion chart.

SIMO Chart

Simultaneous motion cycle chart (SIMO chart) is a recording technique for micro-motion study. A SIMO chart is a chart based on the film analysis, used to record simultaneously on a common time scale the Therbligs or a group of Therbligs performed by different parts of the body of one or more operators.

It is the micro-motion form of the man type flow process chart. To prepare SIMO chart, an elaborate procedure and use of expensive equipment are required and this study is justified when the saving resulting from study will be very high.

CHAPTER-4 (MOTION STUDY)

Motion study is part of method study where analysis of the motion of an operator or work will be studied by following the prescribed methods.

Principles of Motion study

There are a number of principles concerning the economy of movements which have been developed as a result of experience and which forms the basis for the development of improved methods at the workplace. These are first used by Frank Gilbreth, the founder of motion study and further rearranged and amplified by Barnes, Maynard and others. The principles are grouped into three headings:

A. Use of the human body.
B. Arrangement of workplace.
C. Design of tools and equipment.

USES OF HUMAN BODY

When possible:

1. The two hands should begin and complete their movements at the same time.
2. The two hands should not be idle at the same time except during periods of rest.
3. Motions of the arms should be made simultaneously.
4. Hand and body motions should be made at the lowest classification at which it is possible to do the work satisfactorily.
5. Momentum should be employed to help the worker, but should be reduced to a minimum whenever it has to be overcome by muscular effort.
6. Continuous curved movements are to be preferred to straight line motions involving sudden and changes in directions.
7. 'Ballistic' (i.e., free swinging) movements are faster, easier and more accurate than restricted or controlled movements.
8. Rhythm is essential to the smooth and automatic performance of a repetitive operation. The work should be arranged to permit easy and natural rhythm wherever possible.
9. Work should be arranged so that eye movements are confined to a comfortable area, without the need for frequent changes of focus.

ARRANGEMENT OF THE WORKPLACE

1. Definite and fixed stations should be provided for all tools and materials to permit habit formation.
2. Tools and materials should be pre-positioned to reduce searching.
3. Gravity fed, bins and containers should be used to deliver the materials as close to the point of use as possible.
4. Tools, materials and controls should be located within a maximum working area and as near to the worker as possible.
5. Materials and tools should be arranged to permit the best sequence of motions.
6. 'Drop deliveries' or ejectors should be used wherever possible, so that the operative does not have to use his hands to dispose of finished parts.
7. Provision should be made for adequate lightning, and a chair of type and height to permit good posture should be provided. The height of the workplace and seat should be arranged to allow alternate standing and seating.

DESIGN OF TOOLS AND EQUIPMENTS

1. The color of the workplace should contrast with that of work and thus reduce eye fatigue.
2. The hands should be relieved of all work of 'holding' the work piece where this can be done by a jig or fixture or foot operated device.
3. Two or more tools should be combined where possible.
4. Where each finger performs some specific movement, as in typewriting, the load should be distributed in accordance with the inherent capacities of the fingers.
5. Handles such as those used on screw drivers and cranks should be designed to permit maximum surface of the hand to come in contact with the handle.
6. Levers, cross bars and wheel bars should be in such position that operator can manipulate them with least body change and with greatest mechanical advantage.

Recording Techniques of Motion Study

Most of the techniques mentioned in method study is used in the motion study. They are as follows:

Macro Motion Study

a. Flow process chart
b. Two handed process chart.

Micro Motion Study

SIMO chart.

CHAPTER-5 (WORK MEASUREMENT)

Work measurement is also called by the name ‘time study’. Work measurement is absolutely essential for both the planning and control of operations. Without measurement data, we cannot determine the capacity of facilities or it is not possible to quote delivery dates or costs. We are not in a position to determine the rate of production and also labor utilization and efficiency. It may not be possible to introduce incentive schemes and standard costs for budget control.

Objectives of Work Measurement

The use of work measurement as a basis for incentives is only a small part of its total application. The objectives of work measurement are to provide a sound basis for:

1. Comparing alternative methods.
2. Assessing the correct initial manning (manpower requirement planning).
3. Planning and control.
4. Realistic costing.
5. Financial incentive schemes.
6. Delivery date of goods.
7. Cost reduction and cost control.
8. Identifying substandard workers.
9. Training new employees.

Techniques of Work measurement in Production Management

For the purpose of work measurement, work can be regarded as:

1. **Repetitive work:** The type of work in which the main operation or group of operations repeat continuously during the time spent at the job. These apply to work cycles of extremely short duration.
2. **Non-repetitive work:** It includes some type of maintenance and construction work, where the work cycle itself is hardly ever repeated identically.

Various techniques of work measurement are:

1. Time study (stop watch technique),
2. Synthesis,
3. Work sampling,
4. Predetermined motion and time study,
5. Analytical estimating.

Time study and work sampling involve direct observation and the remaining are data based and analytical in nature.

1. **Time study:** A work measurement technique for recording the times and rates of working for the elements of a specified job carried out under specified conditions and for analyzing the data so as to determine the time necessary for carrying out the job at the defined level of performance. In other words measuring the time through stop watch is called time study.
2. **Synthetic data:**
   A work measurement technique for building up the time for a job or pans of the job at a defined level of performance by totaling element times obtained previously from time studies on other jobs containing the elements concerned or from synthetic data.
3. **Work sampling:**
   A technique in which a large number of observations are made over a period of time of one or group of machines, processes or workers. Each observation records what is happening at that instant and the percentage of observations recorded for a particular activity, or delay, is a measure of the percentage of time during which that activities delay occurs.
4. **Predetermined motion time study (PMTS):**
   A work measurement technique whereby times established for basic human motions (classified according to the nature of the motion and conditions under which it is made) are used to build up the time for a job at the defined level of performance. The most commonly used PMTS is known as Methods Time Measurement (MTM).
5. **Analytical estimating:**
   A work measurement technique, being a development of estimating, whereby the time required to carry out elements of a job at a defined level of performance is estimated partly from knowledge and practical experience of the elements concerned and partly from synthetic data. The work measurement techniques and their applications are shown in the following table.

Work Measurement techniques in Operations Management

Work measurement techniques and their application

Techniques	*Applications*	*Unit of measurement*
1. Time study	Short cycle repetitive jobs. Widely used for direct work.	Centiminute (0.01 min)
2. Synthetic Data	Short cycle repetitive jobs.	Centi minutes
3. Working sampling	Long cycle jobs/heterogeneous operations.	Minutes
4. MTM	Manual operations confined to one work centre.	TMU (1 TMU = 0.006 min)
5. Analytical estimation	Short cycle non-repetitive job.	Minutes

Time study in Production and Operation Management

Time study is also called work measurement. It is essential for both planning and control of operations. According to British Standard Institute time study has been defined as "The application of techniques designed to establish the time for a qualified worker to carry out a specified job at a defined level of performance."

Steps in Making Time Study

Stop watch time is the basic technique for determining accurate time standards. They are economical for repetitive type of work. Steps in taking the time study are:

1. Select the work to be studied.
2. Obtain and record all the information available about the job, the operator and the working conditions likely to affect the time study work.
3. Breakdown the operation into elements. An element is a instinct part of a specified activity composed of one or more fundamental motions selected for convenience of observation and timing.
4. Measure the time by means of a stop watch taken by the operator to perform each element of the operation. Either continuous method or snap back method of timing could be used.
5. At the same time, assess the operators effective speed of work relative to the observer's concept of 'normal' speed. This is called performance rating
6. Adjust the observed time by rating factor to obtain normal time for each element

   Normal =

Observed time Rating

100

7. Add the suitable allowances to compensate for fatigue, personal needs, contingencies etc. to give standard time for each element.
8. Compute allowed time for the entire job by adding elemental standard times considering frequency of occurrence of each element.
9. Make a detailed job description describing the method for which the standard time is established.
10. Test and review standards wherever necessary. The basic steps in time study are represented by a block diagram in the figure “Steps in time study”

Computation of Standard Time

Standard time is the time allowed to an operator to carry out the specified task under specified conditions and defined level of performance. The various allowances are added to the normal time as applicable to get the standard time “Components standard time”.

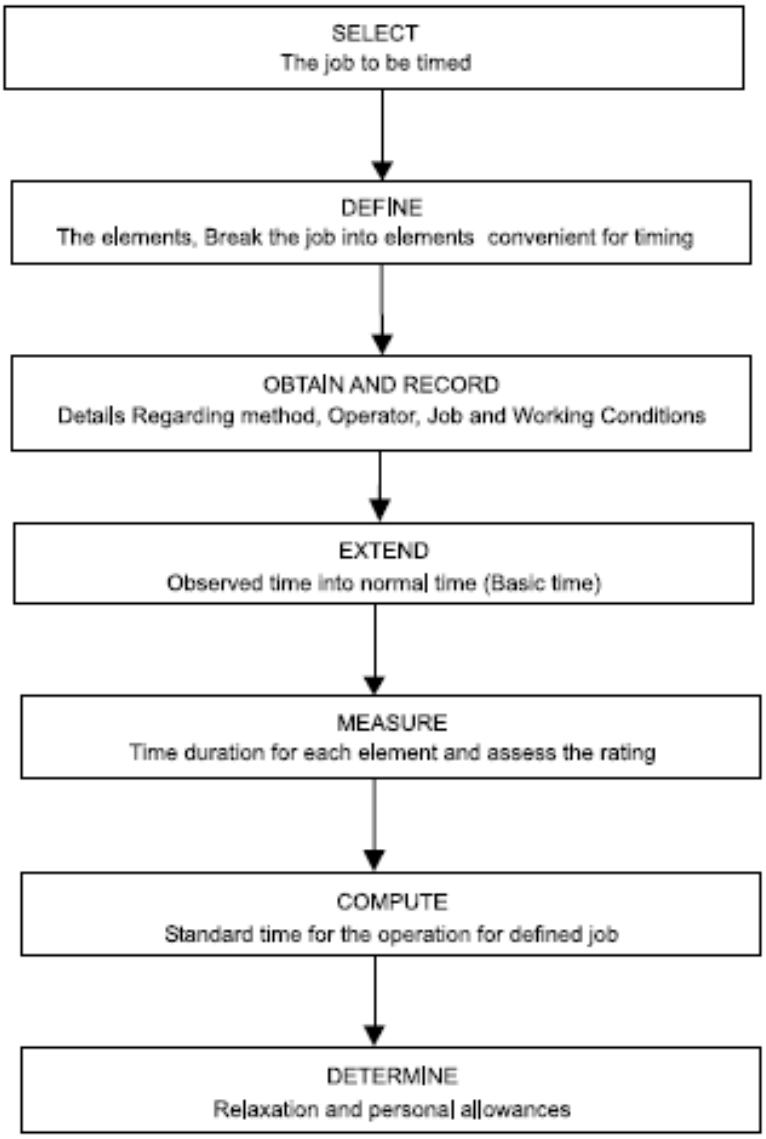
Standard time Calculation time study

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

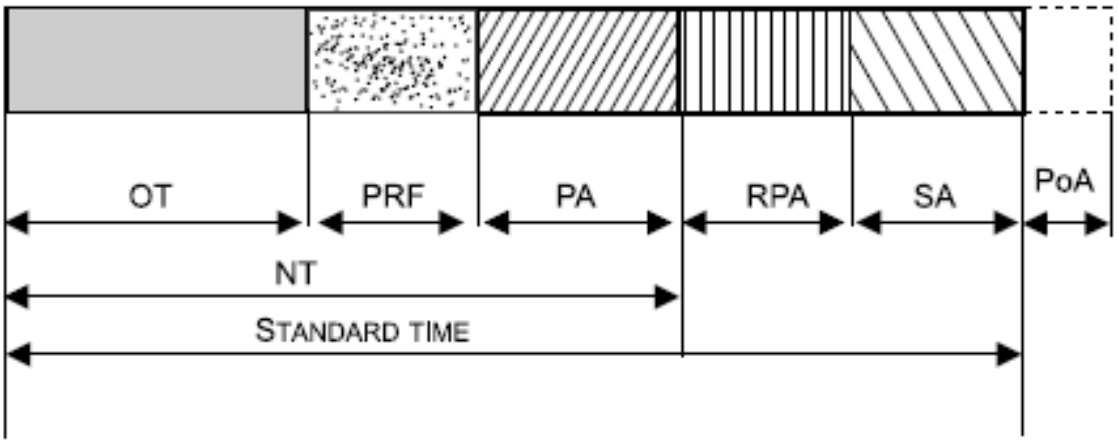
Thus basic constituents of standard time are:

1. Elemental (observed time).
2. Performance rating to compensate for difference in pace of working.
3. Relaxation allowance.
4. Interference and contingency allowance.
5. Policy allowance.

Steps in time study



Components standard time



OT	–	Observed Time
PRF	–	Performance Rating Factor
NT	–	Normal Time
PA	–	Process Allowances
RPA	–	Rest and Personal Allowances
SA	–	Special Allowances
PoA	–	Policy Allowances

Allowances

The normal time for an operation does not contain any allowances for the worker. It is impossible to work throughout the day even though the most practicable, effective method has been developed.

Even under the best working method situation, the job will still demand the expenditure of human effort and some allowance must therefore be made for recovery from fatigue and for relaxation. Allowances must also be made to enable the worker to attend to his personal needs. The allowances are categorized as:

1. Relaxation allowance,
2. Interference allowance, and
3. Contingency allowance.

RELAXATION ALLOWANCE

Relaxation allowances are calculated so as to allow the worker to recover from fatigue. Relaxation allowance is a addition to the basic time intended to provide the worker with the opportunity to recover from the physiological and psychological effects of carrying out specified work under specified conditions and to allow attention to personal needs. The amount of allowance will depend on nature of the job.

Relaxation allowances are of two types: fixed allowances and variable allowances.

Fixed allowances constitute:

a. **Personal needs allowance:**

It is intended to compensate the operator for the time necessary to leave, the workplace to attend to personal needs like drinking water, smoking, washing hands. Women require longer personal allowance than men. A fair personal allowance is 5% for men, and 7% for women.

b. **Allowances for basic fatigue:**

This allowance is given to compensate for energy expended during working. A common figure considered as allowance is 4% of the basic time.

VARIABLE ALLOWANCE

Variable allowance is allowed to an operator who is working under poor environmental conditions that cannot be improved, added stress and strain in performing the job. The variable fatigue allowance is added to the fixed allowance to an operator who is engaged on medium and heavy work and working under abnormal conditions. The amount of variable fatigue allowance varies from organization to organization.

INTERFERENCE ALLOWANCE

It is an allowance of time included into the work content of the job to compensate the operator for the unavoidable loss of production due to simultaneous stoppage of two or more machines being operated by him. This allowance is applicable for machine or process controlled jobs. Interference allowance varies in proportion to number of machines assigned to the operator. The interference of the machine increases the work content.

CONTINGENCY ALLOWANCE

A contingency allowance is a small allowance of time which may be included in a standard time to meet legitimate and expected items of work or delays. The precise measurement of which is uneconomical because of their infrequent or irregular occurrence.

This allowance provides for small unavoidable delays as well as for occasional minor extra work: Some of the examples calling for contingency allowance are:

- Tool breakage involving removal of tool from the holder and all other activities to insert new tool into the tool holder.
- Power failures of small duration.
- Obtaining the necessary tools and gauges from central tool store. Contingency allowance should not exceed 5%.

POLICY ALLOWANCE

Policy allowances are not the genuine part of the time study and should be used with utmost care and only in clearly defined circumstances.The usual reason for making the policy allowance is to line up standard times with requirements of wage agreement between employers and trade unions.

The policy allowance is an increment, other than bonus increment, applied to a standard time (or to some constituent part of it, e.g., work content) to provide a satisfactory level of

earnings for a specified level of performance under exceptional circumstances. Policy allowances are sometimes made as imperfect functioning of a division or part of a plant.

ILLUSTRATION 1: Assuming that the total observed time for an operation of assembling an electric switch is 1.00 min. If the rating is 120%, find normal time. If an allowance of 10% is allowed for the operation, determine the standard time.

SOLUTION:

Obsessed time (or) selected time = 1.00 min

Rating = 120%

Allowance = 10%

As we know that, normal time = Observed time $\times \frac{\text{Rating \%}}{100}$

$= 1.00 \times \frac{120}{100} = \mathbf{1.20\ min}$

Allowance @ 10% $= 1.20 \times \frac{10}{100} = \mathbf{0.12\ min}$

$\therefore$ Standard time = Normal time + Allowances

$= 1.20 + 0.12 = \mathbf{1.32\ min.}$

ILLUSTRATION 2: *An operator manufactures 50 jobs in 6 hours and 30 minutes. If this time includes the time for setting his machine. Calculate the operator's efficiency. Standard time allowed for the job was:*

Setting time = 35 min

Production time per piece = 8 min

SOLUTION:

As standard time = Set up time + Time per piece × No. of pieces produced

$\therefore$ Standard time for manufacturing 50 jobs

$= 35 + 8 \times 50$

$= 435$ min

$= 7$ hours and 15 min.

Efficiency of operator $= \frac{\text{Standard time} \times 100}{\text{Actual time}}$

$= \frac{435 \times 100}{390} = \mathbf{111.5\%.}$

ILLUSTRATION 3: *Following datas were obtained by a work study. Man from a study conducted by hours.*

(*i*) ***Maintenance time***

(*a*) *Get out and put away tools* = *12.0 min/day*
(*b*) *Cleaning of machine* = 5.0 min/day
(*c*) *Oiling of machine* = 5.0 min/day
(*d*) *Replenish coolant supply* = 3.0 min/day

(*ii*) ***Interruption***

(*a*) *Interruption by foreman* = *5.0 min/day*
(*b*) *Interruption by porter etc.* = *4.0 min/day*
(*iii*) *Delay time due to power failure etc.* = *6.0 min/day*
(*iv*) *Personal time* = *20.0 min/day*

Calculate total allowances, total available cycle time productive hours, considering a working day of 8 hours.

SOLUTION:

Total allowance (sometimes also known as station time)

= Total maintenance time + Interruption time + Delay time + Personal time
= (12.0 + 5 + 5 + 3.0) + (5.0 + 4.0) + 6.0 + 20.0
= 25.0 + 9.0 + 6.0 + 20.0
= 60.0 min per day

∴ Total available cycle time = Total work period – Total allowances
= 480 – 60 = **420 min/day**

$$\text{Productive hours} = \frac{\text{Time available}}{\text{Number of hours}}$$

$$= \frac{420}{8} = \mathbf{52.5\ min.}$$

ILLUSTRATION 4: *Find out the standard time using the following data:*

Average time for machine elements = *6 min*
Average time for manual elements = *4 min*
Performance rating = *110%*
Allowances = *10%*

SOLUTION:

Normal time = Machinery time + Manual time × Rating
= 6 + 4 × 1.1
= 6 + 4.4 = **10.4 min**

∴ Standard time = Normal time + Allowances

$$= 10.4 + 10.4 \times \frac{10}{100}$$

$$= 10.4\ (1 + 0.1) = \mathbf{11.44\ min.}$$

CHAPTER-6 (WAGES and INCENTIVES)

Definitions:

"A wage may be defined as the sum of money paid under contract by an employer to worker for services rendered." -Benham

"Wages is the payment to labour for its assistance to production." -A.H. Hansen

'Wage rate is the price paid for the use of labour." -Mc Connell

Types of Wages:

In real practice, wages are of many types as follows:

1. Piece Wages:

Piece wages are the wages paid according to the work done by the worker. To calculate the piece wages, the number of units produced by the worker are taken into consideration.

2. Time Wages:

If the labourer is paid for his services according to time, it is called as time wages. For example, if the labour is paid Rs. 35 per day, it will be termed as time wage.

3. Cash Wages:

Cash wages refer to the wages paid to the labour in terms of money. The salary paid to a worker is an instance of cash wages.

4. Wages in Kind:

When the labourer is paid in terms of goods rather than cash, is called the wage in kind. These types of wages are popular in rural areas.

5. Contract Wages:

Under this type, the wages are fixed in the beginning for complete work. For instance, if a contractor is told that he will be paid Rs. 25,000 for the construction of building, it will be termed as contract wages.

Concepts of Wages:

The following are the two main concepts of wages:

A. Nominal Wage:

B. Real Wage:

A. Money Wages or Nominal Wages:

The total amount of money received by the labourer in the process of production is called the money wages or nominal wages.

B. Real Wages:

Real wages mean translation of money wages into real terms or in terms of commodities and services that money can buy. They refer to the advantages of worker's occupation, i.e. the amount of the necessaries, comforts and luxuries of life which the worker can command in return for his services.

An example will make the things clear. Suppose 'A' receives Rs. 500 p.m. as money wages during the year. Suppose also that midway through the year the prices of commodities and services, that the worker buys, go up, on the average, by 50%.

It means that though the money wages remain the same, the real wages (consumption basket in terms of commodities and services) are reduced by 50%. Real wages also include extra supplementary benefits along with the money wages.

Distinction between Real and Money Wages:

Adam Smith has distinguished the money wages and real wages on the following basis:

1. Relation with Price:

Keeping all other things constant, there exists inverse relation between real wages and price i.e. with the increase in price level real wages tend to decline and vice-versa.

2. Money and Real Wages:

Ceterus paribus, an increase in money wages will lead to an increase in real wages. It is due to the reason that with the increase in money wages, a labourer can purchase more goods and services than before.

The wage rate is fixed on hourly, daily weekly, fortnightly or monthly on the basis of the nature of work. The time is the prevalent rate of the industry or area. The rate may either be a fixed one or there may be a progressive scale of pay that starts at minimum and rises up to a maximum, in various stages by way of increments.

The following formula is followed to calculate the earnings of the worker.

Earnings = No. of Hours Worked x Rate Per Hour.

TYPES OF WAGES SYSTEM:

1. TIME RATE OR TIME WAGE SYSTEM

2. STRAIGHT PIECE RATE SYSTEM

1. TIME RATE OR TIME WAGE SYSTEM

Time rate or time wage system is one of the payment systems or wage measuring method which companies usually adopts when paying an employee.

This wage measuring system is one of the essential features of any business. The company needs to look into the matters of the wage or salary rates, which should be given the employees of the company.

Suitability of Time Rate System of Wage Payment

The time rate system is highly suitable in the case of High skilled workers.

1. High-skilled workers.

2. Unskilled workers.

3. Trainees.

4. Newly recruited workers.

5. Work is being beyond the control of the worker.

6. Work is being dependent on the output of the previous worker.

7. Work is being not measurable in terms of homogeneous units.

8. Work requires close supervision.

9. The output should be a quality.

10. Apprentices.

11. There is not possibility of fixing of standard time.

12. Work does not require speed in completion.

13. Productivity is not commensurate with the incentive paid.

Advantages of Time Rate System of Wage Payment

The following are the advantages of time rate wage system.

1. The calculation of earnings is very easy and requires less clerical work.

2. The calculation of earnings does not create any suspicion in the minds of the worker.

3. A worker is assured of wages as per the specified time spent by him/her in the production area.

4. The quality of output is maintained.

Disadvantages of Time Rate System of Wage Payment

The following are the disadvantages of time rate wage system.

1. This system does not encourage efficient workers.

2. There is no recognition of the efficiency of workers.

3. Both, efficient and inefficient workers are treating equally by the management.

4. It develops idleness on the part of workers.

5. Wages are paid for idle time unnecessarily.

6. There is a possibility of decreasing output.

7. The supervision cost is increased gradually.

8. Work schedule cannot be maintained.

2. STRAIGHT PIECE RATE SYSTEM

is the simplest method of payment by result in which payment is made according to the number of units produced at a fixed rate per unit.

Another type of the straight piece rate method is piece rate with guaranteed time rate in which the worker is guaranteed the time rate with an opportunity of getting piece wages if his earnings according to piece rate system are more than his time wage earnings.

Advantages:

Piece rate system has the following advantages:

1. Workers are paid according to their merits because distinction is made between efficient and inefficient workers. An efficient worker can earn more wages because wages are linked to output. Thus, this method is an improvement on the time wage system.

2. An inducement is given to the workers to increase their production and as a result workers will try to adopt better methods of production to increase their production to earn more wages.

3. Increased production will reduce fixed expenses per unit and cost of production will reduce, allowing a greater margin of profit to the employee

4. Idle time is not paid for as is the case under the time wage system. Thus, idle time will be reduced to minimum.

5. The employer is able to know his exact labour cost per unit which will help him in making quotations confidently.

6. Workers use their tools and machinery with a greater care so that the production may not be held up on account of their defective tools and machinery.

7. Less supervision is required because workers have the fear of not earning wages if they do not work.

8. Inefficient workers are motivated to become efficient and earn more wages by producing more.

Disadvantages:

1. Considerable difficulty is experienced in fixing a suitable piece work rate. Low piece work rate fixed by the employer will frustrate the workers and will not provide any inducement to the workers to increase the production. Thus, equitable piece work rates should be fixed if the piece rate system is to be successful.

2. The quality of the output will suffer because workers will try to produce more to earn more wages. Strict supervision and inspection is necessary to ensure the quality of the goods produced.

3. There may not be an effective use of material because of the efforts of workers to increase the production. Haste makes waste. Thus, there will be more wastage of materials.

4. Increased production does not necessarily mean lower cost of production. Cost of production may increase due to more wastage of materials, high cost of supervision and inspection and high tools cost.

5. Increased production will not reduce the labour cost per unit because the same rate will be paid for all units. On the other hand, increased production will reduce the labour cost per unit under the time wage system.

6. Workers have the fear of losing wages if they are not able to work due to some reason.

7. Workers may work for long hours to earn more wages, and thus, may spoil their health.

8. Workers may work at a very high speed for a few days, earn good wages and then absent themselves for a few days, upsetting the uniform flow of production.

9. Workers in the habit of producing quality goods will suffer because they will not get any extra remuneration for the good quality.

10. The system will cause discontentment among the slower workers because they are not able to earn more wages.

This Method Can be Successfully Applied When:

(i) The work is of a repetitive type.

(ii) Quantity of output can be measured.

(iii) Quality of goods can be controlled.

(iv) It is possible to fix an equitable and acceptable piece rate.

(v) Reasonable rates are fixed so that workers may get a chance to earn more wages.

(vi) The system is flexible and rates can be adjusted to changes in the price level.

(vii) Materials, tools and machines are sufficiently available to cope with the possible increase in production.

(viii) Time cards are maintained to make workers punctual and regular so that production may not slow down.

INCENTIVES

Anything that can attract an employee's attention and motivate them to work can be called as incentive. An incentive aims at improving the overall performance of an organization. Incentives can be classified as direct and indirect compensation. They can be prepared as individual plans, group plans and organizational plans.

Definition:

1. According to Milton L. Rock, incentives are defined as 'variable rewards granted according to variations in the achievement of specific results'.

2. According to K. N. Subramaniam, 'incentive is system of payment emphasizing the point of motivation, that is, the imparting of incentives to workers for higher production and productivity'.

Types of incentives:

Incentives can be classified into three categories:

1. Financial incentives:

Some extra cash is offered for extra efficiency. For example, profit sharing plan and group incentive plans.

2. Non-financial incentives:

When rewards or prizes are provided by the organization to motivate the employees it is known as non-financial incentives.

3. Monetary and non-monetary incentives:

Many times, employees are rewarded with monetary and non-monetary incentives that include promotion, seniority, recognition for merits, or even designation as permanent employee.

Advantages of incentive Plan:

1. Incentive plans motivate workers for higher efficiency and productivity.

2. It can improve the work-flow and work methods.

3. Incentive plans make employees hardworking and innovative.

4. When employees are dedicated, supervision costs can be reduced.

5. The National Commission on Labour says that under our conditions, wage incentives are the cheapest, quickest, and sure means of increasing productivity.

6. Incentive plans help establish positive response in an organization.

7. It helps workers improve their standard of living.

8. The other benefits offered by incentive plans are reduced turnover, reduced absenteeism, and reduced lost time.

Disadvantages of Incentive Plan:

1. Incentive plans can lead to disputes among workers, since some earn more than others.

2. Hunger for money among the workers forces them to overwork, which may affect their heath.

3. Some workers may involve in malpractices in order to earn more money.

4. For enhanced incentives, they may sacrifice quality.

5. It also leads to corruption by falsifying the production records.

6. Incentive plans can create tensions among different personnel.

CHARACTERSTICS OF GOOD INCENTIVE PLAN

1. Simple to Understand:

The plan must be simple, easy to understand and to operate. It should involve least clerical work. The workers should be able to know the extra payments to be given to them. If the method of determining wages involves difficult calculations, then workers may find difficulty in calculating their wages. In spite of correct wages, there may be suspicion in the minds of workers about wages paid to them.

2. Just and Equitable:

Just and equitable system will be successful. A worker should be awarded for the work done by him. This does not mean that there should be undue load on the employers but wages paid must be commensurate with the efforts of workers.

3. Attraction for Workers:

Incentive payments should be sufficient to attract workers for improving their performance. If the incentive is small then workers will not fell tempted towards it. If person is getting Rs. 1800 per month as wages and is offered Rs. 450 more for raising his output, this will not be a good incentive for him. On the other hand, if he is offered Rs.200 to Rs. 300 as extra wages then he will feel tempted to earn. So incentive should be large enough, so that workers are tempted to earn it.

4. Attainable Standards:

The standards fixed under incentive plans be attainable with some extra efforts. If the standards are such that these are not attainable even with extra effort, then workers will feel

discouraged. They may not even try to achieve them. The standards should be such, which may be achieved by average workers also. A standard which may be achieved only by few workers will not make plan ideal.

5. Conducive to Health:

A scheme should not tempt workers to overstrain them. When an incentive plan is such where workers are required to work for long hours or expected to work at much faster speed, then their health maybe adversely affected. There may be a calling on the maximum earnings by the workers in a week or month so that they do not overstrain themselves for longer periods.

6. Willingness of Workers:

The scheme should have willing support of workers. Before introducing an incentive scheme, it should be discussed with workers and their viewpoints should be incorporated as for as possible in the welfare scheme.

7. Clarity of Objectives:

Management should be clear about the goals to be achieved from the incentive schemes, It should be properly communicated to the workers also. The aim of such schemes may be to raise output, improve quality of products, etc. When workers are not clear about the aims of such schemes, then they will not be able to work for their achievement. So, objective of incentive scheme should be decided and made clear to all the concerned persons.

8. Incentive for Quantity and Quality:

The scheme should provide incentive for both quality and quantity of production. It should preferably be based on Time Study basis.

9. Standardization:

It should provide basis for all incentive schemes. All parameters like methods of working, input materials, work place and working conditions should be standardized.

10. Worker's Incentive Earnings:

Workers should not suffer in his earnings for reasons like improper tooling or faulty materials, which are beyond his control. There should be no limit put on a workers incentive earning.

11. Intimation of Efficiency:

Workers Employees should be intimated of their past efficiency immediately. The information may go with their pay slip on which his basic and incentive earnings should be indicated separately.

12. Right to Change Standards:

Management must have the right to change standards when new methods and equipment are introduced in the working system. There should be no compromise on standards being maintained by the organization.

TYPES OF INCENTIVE PLAN

The types are: 1. Time Based Plan 2. Production Based Plans 3. Group Incentive Plans.

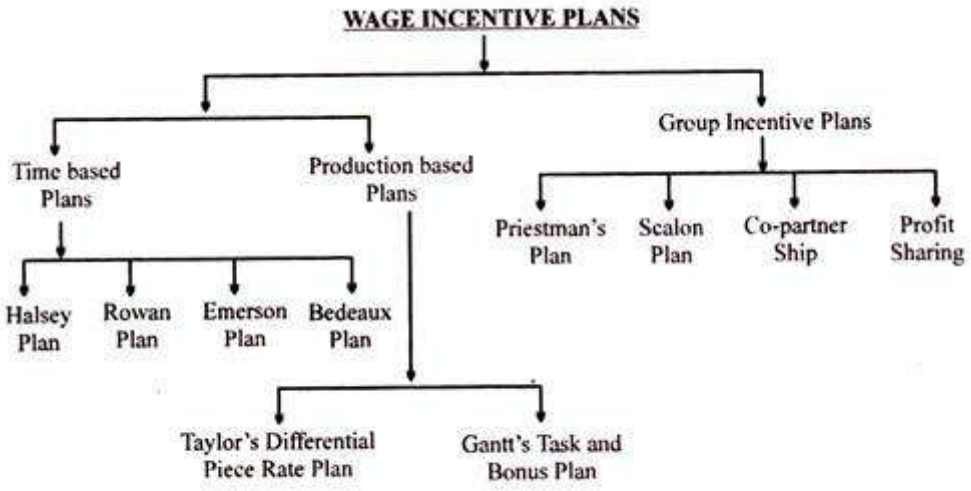


Fig. 13.1: General Classification of Wage Incentive Plans

Wage Incentive Plan: Type # 1. Time Based Plan:

(i) Halsey Plan:

This plan was first designed by Halsey in 1890. Under this plan a standard time is fixed for completing a work in advance. A person taking standard or more time is paid for the time taken by him.

A worker completing his task in less than the standard time is paid for some of the time saved. The payments for time saved vary from 33 ⅓% to 66⅔% but generally wages for one half of time saved are paid. The wage of a worker is given by

$W = T \times R + (S - T/2) R$

Where S= Standard time or allowed time to complete the job.

T = Time taken

R = Hourly wage rate

Example:
Time allowed for a job Actual Time taken Hourly wage rate Calculate the wage of a worker.

Solution: Given
Standard time S = 18 hours

Time T = 14 hours

Hourly wage rate = Re. 1.0

Using the relation

W = T x R + ((S-T/2) R

= 14 x 1 + (18-14/2) x 1

= 14 + 2 = Rs. 16.

In this equation a worker gets Rs. 2.00 as incentive for saving 4 hours i.e. it is a 50-50 Halsey plan. In this case the total saving of 4 hours amounts to Rs. 4 the 50% saving goes to management and 50% to worker who has saved time.

Advantages of Halsey Plan:
1. It guarantees minimum wages to all workers, whether efficient or inefficient.

2. Efficient workers are induced to show better results by offering them additional wages as incentive.

3. The employer also gains under this system because workers are not paid for full time saved by them and fifty percent goes to management.

4. This method is very simple. Workers can make their calculations very easily.

5. There is no need to over speed because incentive is not for more production but for time saved as is clear from above example.

Limitations of Halsey Plan:

1. The workers are not given full reward to their efforts. Normally they are paid for half of the time saved and not for full time. This may discourage workers.

2. It may be difficult to fix standard time for completing a job.

3. The quality of products suffers because workers try to complete the work in shortest possible time.

(ii) Rowan Plan:

This system is similar to that of Halsey plan. A worker is guaranteed minimum wages for time spent on the job. He gets bonus for completing the job in less than the standard time. The only difference between Halsey and Rowan Plans is the method of calculating bonus is that proportion of the wages of the time taken which he saved bears to the standard time allowed.

Wages are calculated by the following relations:

$W = T \times R + (S-T/S) \times T \times R$

Example. 1:

Standard Time: 32 hours

Actual Time taken: 26 hours

Hourly Rate: 4

Solution:

$26 \times 4 + (32-26) = 104 + 6/32 \times 26 \times 4$

$= 104 + 19.50 =$ Rs. 123.50

The additional bonus, a worker will get is Rs. 19.50 in this case. However, the total saving of 6 hours amounts to Rs. 24 so Rs. 4.50 goes to management and Rs. 19.50 to worker.

Advantages of Rowan Plan:

1. This method provides minimum wages to workers.

2. The worker is not induced to rush through the work because bonus increases at a decreasing rate at higher levels of efficiency. Thus the quality of goods under this system will not suffer.

3. Labour cost per unit is reduced because time saved is shared by the worker and management both.

4. The increase in production will reduce overhead cost per unit produced.

Disadvantages of Rowan Plan:

1. The calculation of bonus under this system is complicated. In Halsey plan workers know that he will get additional wages for half of the time saved. In this method a certain proportion of time saved is paid as incentive. The calculation involved is difficult for workers to understand.

2. This method is unjust for efficient workers since bonus is paid at decreasing rate.

3. Labour cost is generally higher in this method.

(iii) Emerson Plan:

Emerson, an associate of F.W. Taylor, developed this efficiency plan in 1910. A standard output is fixed for determining the efficiency of workers. A worker reaching up to 66⅔% of efficiency is paid only minimum wages and bonus is paid only when his efficiency crosses this limit. The rate or bonus increases with the increase in efficiency.

For example, 2000 units are fixed as a standard production, a person producing 2000 units achieves 100%- efficiency, another person producing 1600 units reaches 80% efficiency and so on.

Under this plan bonus is 20% of wages earned at 100% efficiency and increases by 1% with every percent increase in efficiency. If efficiency is 110% then bonus will be 30% at this level. Efficiency of workers is well acknowledged in this system.

Benefits of Emerson Plan:

1. It is simple easily understandable by workers.

2. Workers get security because minimum wages are paid if efficiency is upto 66⅔—% .

3. It provides stimulus to workers for increasing their efficiency. The rate of bonus increases progressively so provides encouragement for improving efficiency.

4. It provides incentive even to beginners and less efficient persons.

Limitations of Emerson Plan:

1. Standards may be set fairly high and workers may not be able to achieve them.

2. Workers may not be encouraged to increase their output beyond the standard level because benefits may be nominal after that level.

3. The records of standards will have to be kept separately for different categories of workers. It increases clerical work.

(iv) Bedeaux Plan:

This plan was devised by Charles E. Bedeaux in 1911. It provides comparable standards for all workers. The benefit of time saved goes both to the worker and his supervisor in the ratio of 3/4 and 1/4th respectively. A supervisor also helps a worker in saving his time so he is also given some benefit in this method.

The standard time for each job is determined in terms of minutes which are called Bedeaux points or B's. Each B represents one minute through time and motion study. A worker is paid time wages up-to standard B's or 100% performance. Bonus is paid when actual performance exceeds standard performance in tenns of B's.

Advantages of Bedeaux Plan:

1. It ensures minimum wages to all workers.

2. This method is very simple and is easy to understand.

3. The supervisor is motivated to co-operate with the workers for increasing their efficiency.

Limitations of Bedeaux Plan:

1. Workers are tempted to hurry up with the job and strict supervision will be necessary for maintaining proper quality control.

2. Workers resent sharing of their efforts with supervisors or superior.

3 The standard task may be too difficult to perform within a specified time.

Wage Incentive Plan: Type # 2. Production Based Plans:

(i) Taylor's Differential Piece-Rate Plan:

F.W. Taylor started this method as a part of the scheme of scientific management. The underlying principle of this system is to reward an efficient worker and penalise the inefficient person. In Taylor's system, inefficient persons have no place in his organization.

The standard time was fixed for completing a task with the help of time and motion study. If a worker completes the task in the standard time he is paid at higher rate and lower rate is paid if more than the standard time is taken.

The main features of this system are:

1. Minimum wages are not guaranteed in this plan.

2. A standard time fixed for taking and completing the task.

3. Different rates are fixed for taking standard time or more.

4. Higher rate is given if work is completed in standard or less time and lower rate is offered if more than standard time is taken.

This method can be explained with the help of an example. A standard output of 200 units is fixed in an 8 hours' time. A rate of 45P is paid if the output is 200 or more units and 35P, if production is less than 200 units. Worker A has produced 240 units and B produced 180 units. The wages to be paid to worker A will be Rs. 108 i.e. (240 x 0.45) and that to B will be Rs. 63 i.e. (180 x 0.35).

Advantages:

1. This method is simple to understand and wages to be paid to a worker can easily be calculated.

2. It offers good incentives to efficient workers.

3. This method is preferred by employees because it reduces overhead expenses per unit by raising output.

Limitations:

1. This method punishes slow workers very severely by giving them lower rates hence less wages.

2. A seed of disunity is sown among workers. Those producing them will feel jealous of others.

3. Workers are not guaranteed minimum wages and they feel insecure about their earnings.

4. It adversely affects the health of workers because they try to over exert for reaching the standard output.

5. It is difficult to determine labour cost because different rates are paid for production purposes.

(ii) Gantt's Task and Bonus Plan:

This method is named after H. L. Gantt, a close associate of F.W.T. Taylor. He tried to improve Taylor's method of wage payment. The workers are guaranteed minimum wages for taking standard time or more. A person taking less than the standard time gets time wages plus bonus.

The characteristics of this scheme are as follows:

1. A standard time is fixed for completing the work, and

2. A worker taking standard or more time gets wages on hourly rate.

3. A bonus ranging from 25% to 50% is paid for completing the task in less than standard time.

An example is given to explain payment under this method. A standard time of 10 hours is allowed to complete a task and hourly rate is Rs. 5. A person completing the task in 10 hours

will get Rs. 50 as wages. If the same task is completed in 8 hours then wages will be Rs. 12: Rs. 8 will be for time spent and Rs. 4 for bonus (taking 50% as the rate of bonus).

Limitations:

1. Since workers are paid minimum wages, they may not bother to increase their efficiency.

2. The disparity in wages earned by efficient and inefficient workers will be wide and it will create jealousy among them.

Wage Incentive Plan: Type # 3. Group Incentive Plans:

Under individual incentive system workers are paid on the basis of their personal performance. Their wages will be directly linked to their efforts. A worker may improve his remuneration by raising the level of output.

There may be circumstances when individual performance may not be measurable. A number of persons may be associated in completing a task. The work of one person may be influenced by the work of the other. Under such conditions, incentives may be offered for raising group performance.

The industry engaged on assembly type of work as in computers, washing machines and Televisions etc. group incentive plan may be practicable. The performance depends upon the group effort rather than on individual initiative. The incentives are given for raising output beyond a certain level of output. The amount of bonus is divided among all persons associated in completing the task.

Suitability:

Group incentive schemes are suitable under the following situations:

1. When individual performance cannot be measured precisely.

2. The workers comprising a group possess the same type of skill or ability.

3. The completion of the task is linked with the collective efforts of the group.

4. The aim is to provide incentive to indirect workers rather than direct workers.

5. The number of persons constituting a group is not large.

Methods of Distributing Group Bonus:

Many methods are used for distributing bonus some of the commonly used criterion are as follows:

1. If all the persons in the group possess the same type of ability or skill then bonus may be distributed equally among them.

2. When group members are paid wages according to same time scale, bonus may also be divided according to that time scale.

3. If workers earn different amounts of wages then bonus may be distributed in proportion to wages earned by them.

4. Bonus may also be paid on the basis of certain percentage, fixed on the basis of the experience, skill and wages earned by a worker.

Types of Group Incentive Plans:

There may be different schemes for paying group bonus some of these are discussed as follows:

1. Priest-man's Plan:

A standard production is fixed for the whole enterprise under this plan. If productivity exceeds the standard then bonus is paid in accordance with the increase. In case production does not reach the standard then workers get maximum wages only. For example, a standard production of 200,000 units is fixed for the year.

Actual production during the year is 240,000 units since production has gone up by 20% workers will get 20% higher wages as bonus. The workers get sufficient incentive to raise their performance. A team spirit is visible among the workers because production will increase with the collective efforts of various limbs of the organization.

This method does not offer incentive to individual workers. Inefficient workers share the efforts of efficient workers because increased production benefits all the manpower in the organization.

2. Scalon Plan:

This method is named after Joseph Scalon. There is a payment of one percent participating bonus for every one percent increase in productivity under this plan. The bonus is available to all workers except top management.

The entire amount of bonus is not paid every month. A reserve fund of one-half of first fifteen percent is created for off-setting any change in labour cost. In case, this reserve remains unused at the end of the year then this amount is also distributed among workers in the last month of the year and a fresh reserve is created in the year.

3. Co-Partnership:

The employees are offered shares of the enterprise at reduced rates in this plan. The payment is also collected in instalments. The employees share profits of the enterprise as its members.

The underlying idea of this method is to make workers feel as a part of the organization and understand view point of the management. As co-partners they will behave in a responsible manner and will try to make the concern more and more profitable and successful.

4. Profit Sharing:

When shareholders share profits for contributing towards capital then workers should also get a part of profits for contributing their labour. The workers are an integral part of any organization and their contribution to its prosperity should also be rewarded by making them the recipients of profits. This realisation that employees/workers contribute significantly to increase profit has encouraged the adoption of this system.

Profit sharing is a method of remuneration under which an employer undertakes to pay his employees a share in the net profits of an enterprise, in addition to regular wages.

Benefits of Group Incentive Plans:

(1) Easy to implement:

It is easy to implement since measurement of group output is easy than the individual's output.

(2) Low Overhead Cost:

The overhead cost is reduced because of reduced paper work.

In general, individual incentive plans tend to motivate the workers to a larger extent than group incentive plans. With the increased rate of production the unit production cost is reduced.

Limitations of Group Incentive Plans:

(i) Tend to lower the overall productivity.

(ii) Due to uniformity of pay irrespective of individual's lower or higher contribution in a group effort personnel problem arise.

CHAPTER-7 PRODUCTION PLANNING AND CONTROL

Production planning and control is a tool available to the management to achieve the stated objectives. Thus, a production system is encompassed by the four factors. i.e., quantity, quality, cost and time. Production planning starts with the analysis of the given data, i.e., demand for products, delivery schedule etc., and on the basis of the information available, a scheme of utilization of firms resources like machines, materials and men are worked out to obtain the target in the most economical way.

Once the plan is prepared, then execution of plan is performed in line with the details given in the plan. Production control comes into action if there is any deviation between the actual and planned. The corrective action is taken so as to achieve the targets set as per plan by using control techniques.

Thus production planning and control can be defined as the "direction and coordination of firms' resources towards attaining the prefixed goals." Production planning and control helps to achieve uninterrupted flow of materials through production line by making available the materials at right time and required quantity.

The present techno-economic scenario of India emphasize on competitiveness in manufacturing. Indian industries have to streamline the production activities and attain the maximum utilization of firms' resources to enhance the productivity. Production planning and control serves as a useful tool to coordinate the activities of the production system by proper planning and control system. Production system can be compared to the nervous system with PPC as a brain.

Production planning and control is needed to achieve:

1. Effective utilization of firms' resources.
2. To achieve the production objectives with respect to quality, quantity, cost and timeliness of delivery.
3. To obtain the uninterrupted production flow in order to meet customers varied demand with respect to quality and committed delivery schedule.

4. To help the company to supply good quality products to the customer on the continuous basis at competitive rates.

NEED OF PRODUCTION PLANNING AND CONTROL

Production planning is a pre-production activity. It is the pre-determination of manufacturing requirements such as manpower, materials, machines and manufacturing process. Ray wild defines "Production planning is the determination, acquisition and arrangement of all facilities necessary for future production of products."

It represents the design of production system. Apart from planning the resources, it is going to organize the production. Based on the estimated demand for company's products, it is going to establish the production programme to meet the targets set using the various resources.

Production Control

Inspite of planning to the minute details, most of the time it is not possible to achieve production 100 per cent as per the plan. There may be innumerable factors which affect the production system and because of which there is a deviation from the actual plan. Some of the factors that affect are:

1. Non-availability of materials (due to shortage, etc.);
2. Plant, equipment and machine breakdown;
3. Changes in demand and rush orders;
4. Absenteeism of workers; and
5. Lack of coordination and communication between various functional areas of business.

Thus, if there is a deviation between actual production and planned production, the control function comes into action. Production control through control mechanism tries to take corrective action to match the planned and actual production. Thus, production control reviews the progress of the work, and takes corrective steps in order to ensure that programmed production takes place. The essential steps in control activity are:

1. Initiating the production,
2. Progressing, and
3. Corrective action based upon the feedback and reporting back to the production planning.

PRODUCTION PLANNING AND CONTROL FUNCTIONS AND OBJECTIVES

Following are the objectives of production planning and control functions:

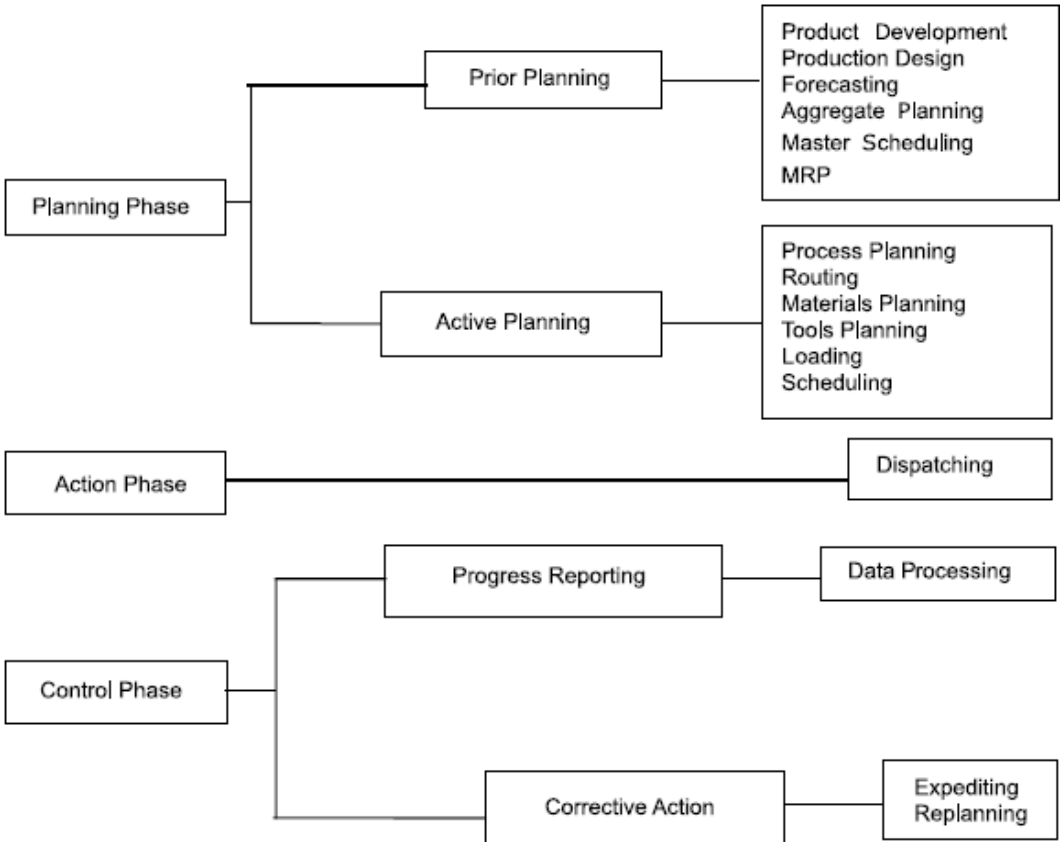
1. Systematic planning of production activities to achieve the highest efficiency in production of goods/services.
2. To organize the production facilities like machines, men, etc., to achieve stated production objectives with respect to quantity and quality time and cost.
3. Optimum scheduling of resources.
4. Coordinate with other departments relating to production to achieve regular balanced and uninterrupted production flow.
5. To conform to delivery commitments.
6. Materials planning and control.
7. To be able to make adjustments due to changes in demand and rush orders.

Stages of Production Planning and Control

The stages of Production planning and control has three phases namely:

A. Planning Phase
B. Action Phase
C. Control Phase

Phases of production planning and control



Planning Phase

Planning is an exercise of intelligent anticipation in order to establish how an objective can be achieved or a need fulfilled in circumstances, which are invariably restrictive. Production planning determines the optimal schedule and sequence of operations economic batch quantity, machine assignment and dispatching priorities for sequencing. It has two categories of planning namely

1. Prior planning
2. Active planning.

PRIOR PLANNING

Prior planning means pre-production planning. This includes all the planning efforts, which are taking place prior to the active planning.

Modules of pre-planning

The modules of prior planning are as follows:

1. **Product development and design** is the process of developing a new product with all the features, which are essential for effective use in the field, and designing it accordingly. At the design stage, one has to take several aspects of design like, design for selling, design for manufacturing and design for usage.
2. **Forecasting** is an estimate of demand, which will happen in future. Since, it is only an estimate based on the past demand, proper care must be taken while estimating it. Given the sales forecast, the factory capacity, the aggregate inventory levels and size of the work force, the manager must decide at what rate of production to operate the plant over an intermediate planning horizon.
3. **Aggregate planning** aims to find out a product wise planning over the intermediate planning horizon.
4. **Material requirement planning** is a technique for determining the quantity and timing for the acquisition of dependent items needed to satisfy the master production schedule.

ACTIVE PLANNING

The modules of active planning are: Process planning and routing, Materials planning. Tools planning, Loading, Scheduling etc.

1. **Process planning and routing** is a complete determination of the specific technological process steps and their sequence to produce products at the desired quality, quantity and cost. It determines the method of manufacturing a product selects the tools and equipments, analyses how the manufacturing of the product will fit into the facilities. Routing in particular prescribes the flow of work in the plant and it is related to the considerations of layout, temporary locations for raw materials and components and materials handling systems.
2. A **material planning** is a process which determines the requirements of various raw materials/subassemblies by considering the trade-off between various cost components like, carrying cost, ordering cost, shortage cost, and so forth.

3. **Tools' planning** determines the requirements of various tools by taking process specification (surface finish, length of the job, overall depth of cut etc.), material specifications (type of material used, hardness of the material, shape and size of the material etc.) and equipment specifications (speed range, feed range, depth of cut range etc.).
4. **Loading** is the process of assigning jobs to several machines such that there is a load balance among the machines. This is relatively a complex task, which can be managed with the help of efficient heuristic procedures.
5. **Scheduling** is the time phase of loading and determines when and in what sequence the work will be carried out. This fixes the starting as well as the finishing time for each job.

Action Phase

Action phase has the major step of **dispatching.** Dispatching is the transition from planning phase to action phase. In this phase, the worker is ordered to start manufacturing the product. The tasks which are included in dispatching are job order, store issue order, tool order, time ticket, inspection order, move order etc.

The **job order** number is the key item which is to be mentioned in all other reports/orders. **Stores issue order** gives instruction to stores to issue materials for manufacturing the product as per product specifications. As per tooling requirements for manufacturing the product, the **tool Order** instruct the tool room to issue necessary tools.

Time ticket is nothing but a card which is designed to note down the actual time taken at various processes. This information is used for deciding the costs for future jobs of similar nature and also for performing variance analysis, which helps to exercise control.
Job order is the official authorization to the shop floor to start manufacturing the product. Generally, the process sequence will contain some testing and inspection. So, these are to be instructed to inspection wing in the form of inspection order for timely testing and inspection so that the amount of rework is minimized. The manufacture of product involves moving raw materials/subassemblies to the main line. This is done by a well-designed materials handling system. So, proper instruction is given to the materials handling facilities for major movements of materials/subassemblies in the form of a move order. Movements which involve less distance and fewer loads are managed at the shop floor level based on requests from operators.

Control Phase

The control phase has the following two major modules:

1. Progress reporting, and
2. Corrective action.

1. **PROGRESS REPORTING**
   In progress reporting, the data regarding what is happening with the job is collected. Also, it helps to make comparison with the present level of performance. The various data pertaining to materials rejection, process variations, equipment failures, operator efficiency, operator absenteeism, tool life, etc., are collected and analyzed for the purpose of progress reporting. These data are used for performing variance analysis, which would help us to identify critical areas that deserve immediate attention for corrective actions.
2. **CORRECTIVE ACTION**
   The tasks under corrective action primarily make provisions for an unexpected event. Some examples of corrective actions are creating schedule flexibility, schedule modifications, capacity modifications, make or buy decisions, expediting the work, pre-planning, and so on. Due to unforeseen reasons such as, machine breakdown, labor absenteeism, too much rejection due to poor material quality etc., it may not be possible to realize the schedule as per the plan. Under such condition, it is better to reschedule the whole product mix so that we get a clear picture of the situation to progress further. Under such situation, it is to be re-examined for selecting appropriate course of action. Expediting means taking action if the progress reporting indicates deviations from the originally set targets. Pre-planning of the whole affair becomes essential in case the expediting fails to bring the deviated plan to its right path.

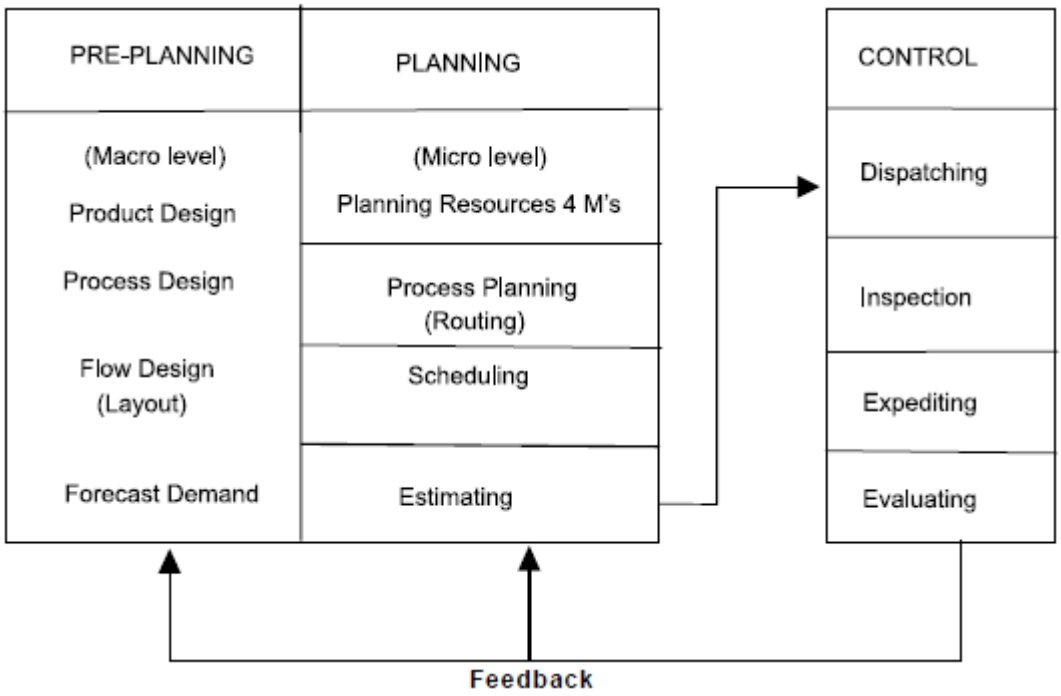
Production Planning and Control Functions

The functions of production planning and controlling are depicted in the following figure.

1. **PRE-PLANNING FUNCTION**

   Pre-planning is a macro level planning and deals with analysis of data and is an outline of the planning policy based upon the forecasted demand, market analysis and product design and development. This stage is concerned with process design (new processes and developments, equipment policy and replacement and work flow (Plant layout). The pre-planning function of PPC is concerned with decision-making with respect to methods, machines and work flow with respect to availability, scope and capacity.

Functions of production planning and control



2. **PLANNING FUNCTION**
   The planning function starts once the task to be accomplished is specified, with the analysis of **four M's**, i.e., Machines, Methods, Materials and Manpower. This is followed by process planning (routing). Both short-term (near future) and long-term planning are considered. Standardization, simplification of products and processes are given due consideration.
3. **CONTROL FUNCTION**
   Control phase is effected by dispatching, inspection and expediting materials control, analysis of work-in-process. Finally, evaluation makes the PPC cycle complete and corrective actions are taken through a feedback from analysis. A good communication, and feedback system is essential to enhance and ensure effectiveness of PPC.

Parameters for PPC

The functions of PPC can be explained with the following parameters:

1. **Materials:** Raw materials, finished parts and bought out components should be made available in required quantities and at required time to ensure the correct start and end for each operation resulting in uninterrupted production. The function includes the specification of materials (quality and quantity) delivery dates, variety reduction (standardization) procurement and make or buy decisions.
2. **Machines and equipment:**This function is related with the detailed analysis of available production facilities, equipment down time, maintenance policy procedure and schedules. Concerned with economy of jigs and fixtures, equipment availability. Thus, the duties include the analysis of facilities and making their availability with minimum down time because of breakdowns.
3. **Methods:**
   This function is concerned with the analysis of alternatives and selection of the best

method with due consideration to constraints imposed. Developing specifications for processes is an important aspect of PPC and determination of sequence of operations.

4. **Process planning (Routing):**
   It is concerned with selection of path or route which the raw material should follow to get transformed into finished product. The duties include:

   a. Fixation of path of travel giving due consideration to layout.
   b. Breaking down of operations to define each operation in detail.
   c. Deciding the set up time and process time for each operation.

5. **Estimating:**
   Once the overall method and sequence of operations is fixed and process sheet for each operation is available, then the operations times are estimated. This function is carried out using extensive analysis of operations along with methods and routing and a standard time for operation are established using work measurement techniques.

6. **Loading and scheduling:**
   Scheduling is concerned with preparation of machine loads and fixation of starting and completion dates for each of the operations. Machines have to be loaded according to their capability of performing the given task and according to their capacity. Thus the duties include:

   a. Loading, the machines as per their capability and capacity.
   b. Determining the start and completion times for each operation.
   c. To coordinate with sales department regarding delivery schedules.

7. **Dispatching:**
   This is the execution phase of planning. It is the process of setting production activities in motion through release of orders and instructions. It authorizes the start of production activities by releasing materials, components, tools, fixtures and instruction sheets to the operator. The activities involved are:

   a. To assign definite work to definite machines, work centers and men.
   b. To issue required materials from stores.
   c. To issue jigs, fixtures and make them available at correct point of use.
   d. Release necessary work orders, time tickets, etc., to authorize timely start of operations.
   e. To record start and finish time of each job on each machine or by each man.

8. **Expediting**: This is the control tool that keeps a close observation on the progress of the work. It is logical step after dispatching which is called ‘follow-up’. It coordinates extensively to execute the production plan. Progressing function can be divided into three parts, i.e., follow up of materials, follow up of work-in-process and follow up of assembly. The duties include:

   a. Identification of bottlenecks and delays and interruptions because of which the production schedule may be disrupted.
   b. To devise action plans (remedies) for correcting the errors.
   c. To see that production rate is in line with schedule.

9. **Inspection:**
   It is a major control tool. Though the aspects of quality control are the separate function, this is of very much important to PPC both for the execution of the current plans and its scope for future planning. This forms the basis for knowing the limitations with respects to methods, processes, etc., which is very much useful for evaluation phase.

10. **Evaluation:**
    This stage though neglected is a crucial to the improvement of productive efficiency. A thorough analysis of all the factors influencing the production planning and control helps to identify the weak spots and the corrective action with respect to pre-planning and planning will be effected by a feedback. The success of this step depends on the communication, data and information gathering and analysis.

Scheduling in Production and Operation Management

Scheduling can be defined as "prescribing of when and where each operation necessary to manufacture the product is to be performed." It is also defined as "establishing of times at which to begin and complete each event or operation comprising a procedure". The principle aim of scheduling is to plan the sequence of work so that production can be systematically arranged towards the end of completion of all products by due date.

Principles of Scheduling

1. **The principle of optimum task size:** Scheduling tends to achieve maximum efficiency when the task sizes are small, and all tasks of same order of magnitude.
2. **Principle of optimum production plan:** The planning should be such that it imposes an equal load on all plants.
3. **Principle of optimum sequence:** Scheduling tends to achieve the maximum efficiency when the work is planned so that work hours are normally used in the same sequence.

Inputs to Scheduling

1. Performance standards: The information regarding the performance standards (standard times for operations) helps to know the capacity in order to assign required machine hours to the facility.
2. Units in which loading and scheduling is to be expressed.
3. Effective capacity of the work centre.
4. Demand pattern and extent of flexibility to be provided for rush orders.
5. Overlapping of operations.
6. Individual job schedules.

Scheduling Strategies

Scheduling strategies vary widely among firms and range from 'no scheduling' to very sophisticated approaches. These strategies are grouped into four classes:

1. **Detailed scheduling:** Detailed scheduling for specific jobs that are arrived from customers is impracticable in actual manufacturing situation. Changes in orders, equipment breakdown, and unforeseen events deviate the plans.
2. **Cumulative scheduling:** Cumulative scheduling of total work load is useful especially for long range planning of capacity needs. This may load the current period excessively and under load future periods. It has some means to control the jobs.
3. **Cumulative detailed:** Cumulative detailed combination is both feasible and practical approach. If master schedule has fixed and flexible portions.

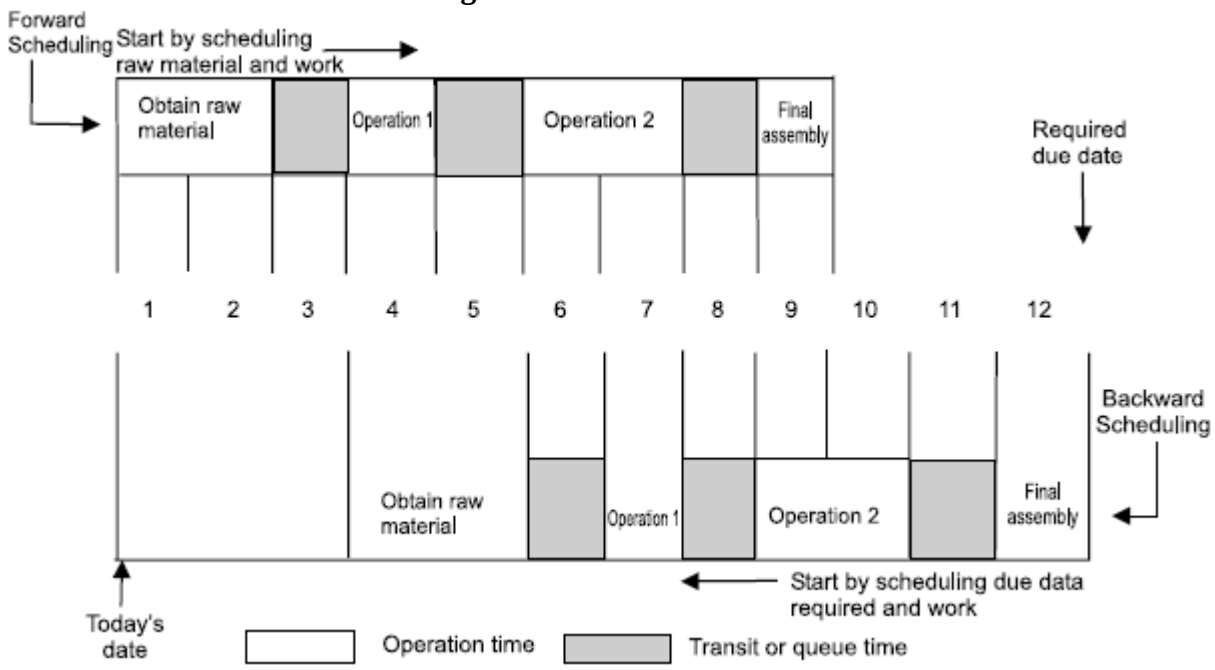
4. **Priority decision rules:** Priority decision rules are scheduling guides that are used independently and in conjunction with one of the above strategies, i.e., first come first serve. These are useful in reducing Work-In-Process (WIP) inventory.

Types of Scheduling

Types of scheduling can be categorized as forward scheduling and backward scheduling.

1. **Forward scheduling**
   is commonly used in job shops where customers place their orders on "needed as soon as possible" basis. Forward scheduling determines start and finish times of next priority job by assigning it the earliest available time slot and from that time, determines when the job will be finished in that work centre. Since the job and its components start as early as possible, they will typically be completed before they are due at the subsequent work centers in the routing. The forward method generates in the process inventory that are needed at subsequent work centers and higher inventory cost. Forward scheduling is simple to use and it gets jobs done in shorter lead times, compared to backward scheduling.
2. **Backward scheduling**
   is often used in assembly type industries and commit in advance to specific delivery dates. Backward scheduling determines the start and finish times for waiting jobs by assigning them to the latest available time slot that will enable each job to be completed just when it is due, but done before. By assigning jobs as late as possible, backward scheduling minimizes inventories since a job is not completed until it must go directly to the next work centre on its routing. Forward and backward scheduling methods are shown in the following figure.

Forward and backward scheduling



The scheduling methodology depends upon the type of industry, organization, product, and level of sophistication required. They are:

1. Charts and boards,
2. Priority decision rules, and
3. Mathematical programming methods.

1. **Gantt Charts and Boards**
   Gantt charts and associated scheduling boards have been extensively used scheduling devices in the past, although many of the charts are now drawn by computer. Gantt charts are extremely easy to understand and can quickly reveal the current or planned situation to all concerned. They are used in several forms, namely,

   a. Scheduling or progress charts, which depicts the sequential schedule;
   b. Load charts, which show the work assigned to a group of workers or machines; and
   c. Record a chart, which are used to record the actual operating times and delays of workers and machines.

2. **Priority Decision Rules**
   Priority decision rules are simplified guidelines for determining the sequence in which jobs will be done. In some firms these rules take the place of priority planning systems such as MRP systems. Following are some of the priority rules followed.

Symbol	*Priority rule*
FCFS	First come, first served
EDO	Earliest due date
LS	Least slack (that is, time due less processing time)
SPT	Shortest processing time
LPT	Longest processing time
PCO	Preferred customer order
RS	Random selection

3. **Mathematical Programming Methods**
   Scheduling is a complex resource allocation problem. Firms process capacity, labor skills, materials and they seek to allocate their use so as to maximize a profit or service objective, or perhaps meet a demand while minimizing costs.
   The following are some of the models used in scheduling and production control.

   a. **Linear programming model:**
      Here all the constraints and objective functions are formulated as a linear equation and then problem is solved for optimality. Simplex method, transportation methods and assignment method are major methods used here.
   b. **PERT/CPM network model:** PERT/CPM network is the network showing the sequence of operations for a project and the precedence relation between the activities to be completed.

Note: Scheduling is done in all the activities of an organization i.e., production, maintenance etc. Therefore, all the methods and techniques of scheduling are used for maintenance management

PERT ANALYSIS

Program Evaluation and Review Technique (PERT) is a method used to examine the tasked that are in a schedule and determine a variation of the Critical Path Method (CPM). It analyzes the time required to complete each task and its associated dependencies to determine the minimum time to complete a project. It estimates the shortest possible time each activity will take, the most likely length of time, and the longest time that might be taken if the activity takes longer than expected.

The basic tool used in PERT technique is the network or flow plan. Network consists of a series of related events and activities. An important point is that, as a person plans the activities in his mind, so the flow plan (or diagram) evolves and, it even points out the gaps in the drawing. The network thus drawn shows, how various activities of a project depend on each other and that certain activities have to be completed before the others can start.

Steps Involved in PERT Planning Techniques:

The PERT planning technique consists of the following steps:

(1) The project is broken down into different activities systematically.

(2) Activities are arranged in logical sequence.

(3) The network diagram is drawn. Events and activities are numbered

(4) Using three times estimate, the expected time for each activity is calculated.

(5) Standard deviation and variance for each activity are computed.

(6) Earliest starting times and latest finishing times are calculated.

(7) Expected time, earliest starting time, and latest finishing times are marked on the network diagram.

(8) Slack is calculated.

(9) Critical path(s) are identified and marked on the network diagram.

(10) Length of critical path or total project duration is found out.

(11) Lastly, the probability that the project will finish at due date is calculated.

Example on PERT:

A small engineering project consists of 9 activities.

Three time estimates for each activity are given in Table 10.2:

TABLE 10.2

DAYS

Activity	t_o	t_m	t_p	t_e	S_t	V_t
1-2	2	5	14	6	2	4
1-6	2	5	8	5	1	1
2-3	5	11	29	13	4	16
2-4	1	4	7	4	1	1
3-5	5	11	17	11	2	4
4-5	2	5	14	6	2	4
6-7	3	9	27	11	4	16
5-8	2	2	8	3	1	1
7-8	7	13	31	15	4	16

The network diagram is given below with T_e, *EST*, *LFT* and critical path marked on the same.

(a) Calculate values of expected time (T_e), standard deviation (S_t) and variance (V_t) for each activity.

(b) Draw the network diagram and mark t_e on each activity.

(c) Calculate EST and LFT and mark them on the network diagram.

(d) Calculate total slack for each activity.

(e) Identify the critical path(s) and mark on the network diagram.

(f) Find the length of critical paths or the total project duration.

(g) Calculate variance of critical path.

(h) Calculate the probability that jobs on critical path will be finished by the due date of 38 days.

(i) Calculate the approximate probability that the jobs on the next most critical path will be completed by the due date of 38 days.

(j) Estimate the probability that the entire project will be completed by the due date of 38 days. Explain it.

(k) If the project due date changes to 35 days what is the probability of not meeting the due date.

(l) Find the due date which has a probability of 94.5% of being met.

Solution:

The concept of expected time and the estimation of variability of activity times (which is necessary before solving the problem) is given below:

1. Estimation of Activity Time:

For dealing with uncertainties associated with different activities, PERT approach computes expected time for each activity from the following three time estimates:

(a) Optimistic Time (t_o):

It is the shortest possible time in which an activity can be completed if everything goes exceptionally well.

(b) Most Likely Time (t_m):

It is the time in which the activity is normally expected to complete under normal contingencies.

(c) Pessimistic Time (t_p):

It is the time which an activity will take to complete in case of difficulty, i.e., if mostly the things go wrong. It is the longest of all the three time estimates.

The t_o, t_m and t_p are combined statistically to develop the expected time (t_e) for an activity. The fundamental assumption in PERT is that the three time estimates form the end points and mode of Beta distribution (Fig. 10.3). It is further assumed that t_p and t_o are about equally likely to occur whereas the probability of occurrence of t is 4 times that of t_p or t_o.

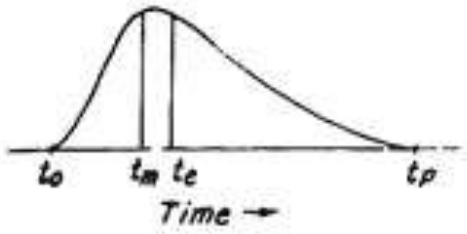


Fig.10.3. PERT time estimates - Beta distribution.

Therefore, t_e is given by,

$$t_e = \frac{t_o + (t_m \times 4) + t_p}{6} \quad ...(i)$$

(2) Estimation of Variability of Activity Times:

The purpose is to find, how reliable-'t_e' as got from equation (1) is;

Assume

Case I	*Case II*
$t_o=5$	$t_o=5$
$t_m=6$	$t_m=10$
$t_p=7$	$t_p=21$
$t_e=\frac{5+(6\times4)+7}{6}$	$t_e=\frac{5+(10\times4)+21}{6}$
$t_e=6$	$t_e=11$
$t_e=t_m$	t_e is not equal to t_m

This indicates that, if the time required for an activity shows high variability (Case II) and there is wide range of (21-5=16) three times estimates, the certainty and confidence to correctly anticipate the actual time from relation (1) decreases and thus the need to measure the variability in the time of an activity arises. Knowing the variability, the reliability of t_e values can be assessed. PERT, using statistical probability concept, employs standard deviation (S_t) and variance (V_t) as measures of variability.

They are given by:

This supports the above concept.

by,

$$S_t=\left[\frac{t_p-t_o}{6}\right] \quad ...(2)$$

$$V_t=\left[\frac{t_p-t_o}{6}\right]^2=(S_t)^2 \quad ...(3)$$

Thus for cases I and II above

$$(S_t)_1=\left[\frac{7-5}{6}\right]=\frac{1}{6}\ ;\ (S_t)_2=\frac{21-5}{6}=2.66$$

$$(V_t)_1=\left[\frac{1}{6}\right]^2=\frac{1}{36};\ (V_t)_2=7.1$$

This supports the above concept.

Coming to the actual problem:

(a) The Table 10.2 gives the values of t_o, t_m and t_p for each activity. The values of t_e, S_t and V_t are calculated by using equations (1), (2), and (3) and have been added in the Table 10.2.

TABLE 10.2

	← DAYS →				
Activity	t_o	t_m	t_p	t_e	S_t	V_t
1-2	2	5	14	6	2	4
1-6	2	5	8	5	1	1
2-3	5	11	29	13	4	16
2-4	1	4	7	4	1	1
3-5	5	11	17	11	2	4
4-5	2	5	14	6	2	4
6-7	3	9	27	11	4	16
5-8	2	2	8	3	1	1
7-8	7	13	31	15	4	16

The network diagram is given below with T_e, *EST, LFT* and critical path marked on the same.

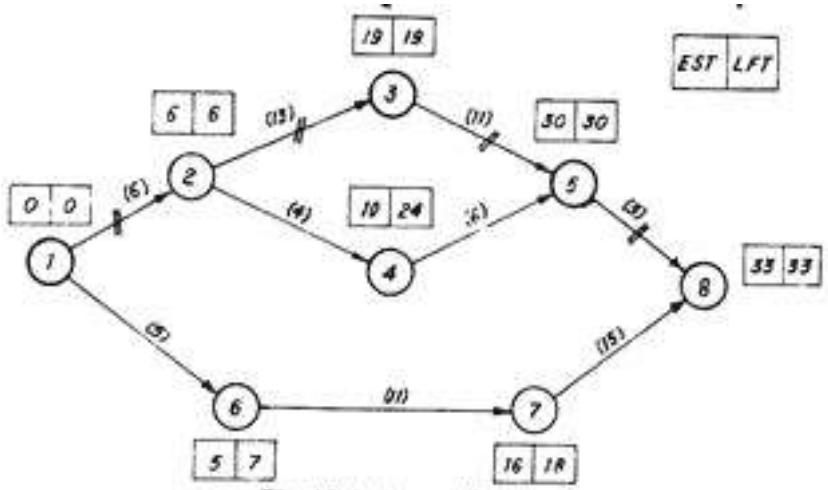


Fig. 10.4. Arrow diagram.

(d) TABLE 10.3

Activity	*EST*	*LST*	*Total slack LST−EST*
1-2	0	0	0
1-6	0	2	2
2-3	6	6	0
2-4	6	20	14
3-5	19	19	0
4-5	10	24	14
6-7	5	7	2
5-8	30	30	0
7-8	16	18	2

(e) Critical path is 1-2-3-5-8 and it is marked on the network diagram.

(J) The length of the critical path or the total project duration (T_e) is sum of the duration of each critical activity, i.e., 6 + 13 + 11 + 3 = 33 days.

(g) Variance of the critical path is sum of the variance of each critical activity, i.e., 4 + 16 + 4 + 1 =25.

(h) The probability that the project will meet the scheduled or the due date is calculated from the following relation:

$$Z = \frac{D - T_e}{S_t} \qquad \text{...(4)}$$

where T_e is the total project duration = 33 days

S_t is the standard deviation

$$= \sqrt{\text{Variance of the project}} = \sqrt{25} = 5$$

D is the due or scheduled date (time) = 38 days.

Z is the number of standard deviations by which D exceeds T_e

Substituting different values in equation (4).

Z = 38-33/5 = 1; for the value of Z=1 the corresponding value of probability can be read from Table 10.4 and this is 0.841.

TABLE 10.4
Standard Normal Distribution

Z	*Probability of meeting due or scheduled date*	*Z*	*Probability of meeting due or scheduled date*
2.8	0.997	−0.2	0.421
2.6	0.995	−0.4	0.345
2.4	0.992	−0.6	0.274
2.2	0.986	−0.8	0.212
2.0	0.977	−1.0	0.159
1.8	0.964	−1.2	0.115
1.6	0.945	−1.4	0.081
1.4	0.919	−1.6	0.055
1.2	0.885	−1.8	0.036
1.0	0.841	−2.0	0.023
0.8	0.788	−2.2	0.014
0.6	0.726	−2.4	0.008
0.4	0.655	−2.6	0.005
0.2	0.579	−2.8	0.003
0.0	0.500		

(i) The next most critical path is 1-6-7-8, of 31 days duration.

Variance of the path = 1 + 16 + 16=33

Therefore, $S_t = \sqrt{33} = 5.74$
And $Z = D\text{-}T_e/S_t = 38\text{-}31/5.74 = 1.22$
From Table 10.4 for Z= 1.22, the approximate probability of meeting due date is 0.888.

(j) To complete the project, there are three paths from first to last event,

(a) 1-2-3-5-3 (33 days)

(b) 1-2-4-5-8 (19 days)

(c) 1-6-7-8 (31 days)

Path (b) involves much less time, so its probability of completing in 38 days is very high.

Paths (a) and (c) are independent of each other and the probabilities of paths (a) and (c) to complete in due time of 38 days are 0.841 and 0.888 respectively. Therefore the probability of their both being completed in 38 days is = 0.841 x 0.888 = 0.7468.

(k) Again $Z = D\text{-}T_e/S_t = 35\text{-}33/5 = 0.4$

From Table 10.4 for Z = 0.4, the probability of meeting due date is 0.655; and hence the probability of not meeting the due date

= 1 – 0.655 = 0.345

(1) From Table 10.4, for the probability of 94.5% or 0.945, the value of Z = 1.6

and $Z = D\text{-}T_e/S_t$, therefore 1.6 = D-33/5
and thus D – 41 days.

Advantages of PERT:

1. PERT forces the management to plan carefully and study how the various parts fit into the whole project.

2. PERT enables the business managers to predict time and cost of the project in advance.

3. PERT is a forward-looking control device for management. PERT calls attention on the timely completion of the project and avoids delay.

4. PERT enables the determination of the probabilities concerning the time by which activity and project would be completed.

5. PERT suggests areas for increasing efficiency and reducing cost.

6. It provides up-to-date information of the project programme so that the necessary steps may be taken to minimize the delays and interruptions.

7. PERT assists in coordinating the different parts of the total projects.

Limitations of PERT:

1. In PERT, it is assumed that all the activities involved in the project are known in advance. In projects like research and development (R and D), it is not possible to list out all the activities in advance.

2. The assumption that a project can be sub-divided into a set of predictable and independent, activities may not hold true always.

3. PERT emphasizes only on time and not the costs.

4. PERT is based on time estimates and there may be error in estimating time.

5. For active control of a project, PERT requires frequent updating and revising of calculations. It is an expansive and time consuming exercise, which requires highly trained personnel.

CRITICAL PATH METHOD

Critical path is the sequential activities from start to the end of a project. Although many projects have only one critical path, some projects may have more than one critical paths depending on the flow logic used in the project.

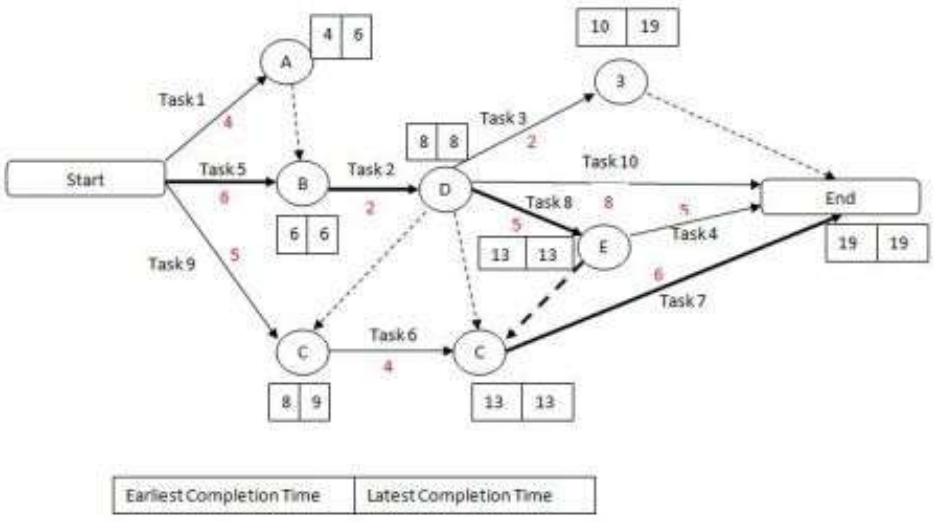
If there is a delay in any of the activities under the critical path, there will be a delay of the project deliverables.

Most of the times, if such delay is occurred, project acceleration or re-sequencing is done in order to achieve the deadlines.

Critical path method is based on mathematical calculations and it is used for scheduling project activities. This method was first introduced in 1950s as a joint venture between Remington Rand Corporation and DuPont Corporation.

The initial critical path method was used for managing plant maintenance projects. Although the original method was developed for construction work, this method can be used for any project where there are interdependent activities.

In the critical path method, the critical activities of a program or a project are identified. These are the activities that have a direct impact on the completion date of the project.



Key Steps in Critical Path Method

Let's have a look at how critical path method is used in practice. The process of using critical path method in project planning phase has six steps.

Step 1: Activity specification

You can use the Work Breakdown Structure (WBS) to identify the activities involved in the project. This is the main input for the critical path method.

In activity specification, only the higher-level activities are selected for critical path method.

When detailed activities are used, the critical path method may become too complex to manage and maintain.

Step 2: Activity sequence establishment

In this step, the correct activity sequence is established. For that, you need to ask three questions for each task of your list.

- Which tasks should take place before this task happens.
- Which tasks should be completed at the same time as this task.
- Which tasks should happen immediately after this task.

Step 3: Network diagram

Once the activity sequence is correctly identified, the network diagram can be drawn (refer to the sample diagram above).

Although the early diagrams were drawn on paper, there are a number of computer softwares, such as Primavera, for this purpose nowadays.

Step 4: Estimates for each activity

This could be a direct input from the WBS based estimation sheet. Most of the companies use 3-point estimation method or COCOMO based (function points based) estimation methods for tasks estimation.

You can use such estimation information for this step of the process.

Step 5: Identification of the critical path

For this, you need to determine four parameters of each activity of the network.

- Earliest start time (ES) - The earliest time an activity can start once the previous dependent activities are over.
- Earliest finish time (EF) - ES + activity duration.
- Latest finish time (LF) - The latest time an activity can finish without delaying the project.
- Latest start time (LS) - LF - activity duration.

The float time for an activity is the time between the earliest (ES) and the latest (LS) start time or between the earliest (EF) and latest (LF) finish times.

During the float time, an activity can be delayed without delaying the project finish date.

The critical path is the longest path of the network diagram. The activities in the critical path have an effect on the deadline of the project. If an activity of this path is delayed, the project will be delayed.

In case if the project management needs to accelerate the project, the times for critical path activities should be reduced.

Step 6: Critical path diagram to show project progresses

Critical path diagram is a live artefact. Therefore, this diagram should be updated with actual values once the task is completed.

This gives more realistic figure for the deadline and the project management can know whether they are on track regarding the deliverables.

Advantages of Critical Path Method

Following are advantages of critical path methods:

- Offers a visual representation of the project activities.
- Presents the time to complete the tasks and the overall project.
- Tracking of critical activities

asis	**PERT**	**CPM**
Full Form	Full form of PERT- Program (Project) Evaluation and Review Technique	Full Form of CPM-Critical Path Method
Meaning	PERT is a technique, used to manage the uncertain task of a project.	CPM is a statistical technique used to manage the activities of a project.
Method	To control time	To control cost and time
Progress	Research and development project	Construction project
Manage	Unpredictable activities	Predictable activities
Appropriate for	Research & Development project	Non-research project. Example-ship building, civil construction

CHAPTER-8 (STORE MANAGEMENT)

Store management is concerned with ensuring that all the activities involved in storekeeping and stock control are carried out efficiently and economically by the **store** personnel. Proper **management** of **store** systems provide flexibility to absorb the shock variation in demand, and enable purchasing to plan ahead

Store Layouts

Since moving merchandise is the name of the game, the store layout should help to achieve that goal by guiding customers through the store, exposing them to product, all while managing important stimuli that encourages purchasing behaviors. How people experience your store is a big part of your brand that needs to be as carefully crafted as other aspects of your brand.

A well-planned retail store layout allows a retailer to maximize the sales for each square foot of their allocated selling space. This is done by featuring merchandise in an efficient way that encourages customers to consider making additional purchases while they browse.

The draft of a store layout generally shows the size and location of each department, any permanent structures, fixture locations, and customer traffic patterns.

Each floor plan and store layout will depend on the type of products sold, the building location, and how much the business can afford to put into the overall store design.

A solid floor plan is the perfect balance of ultimate customer experience and maximized revenue per square foot. Many retailers miss this point. They simply focus on revenue and forget customer experience. Retailers who deliver on experience have higher revenues than those that don't—even if the square footage is comparatively smaller.

For example, some retailers "crowd" the sales floor with lots of merchandise. While this increases selection, it also decreases customer traffic flow space. Many customers are turned off by crowded stores. They prefer cleaner, wider aisles that reduce the stress of shopping. Department stores that adopt the approach of using wider aisles include Macy's and Belk.

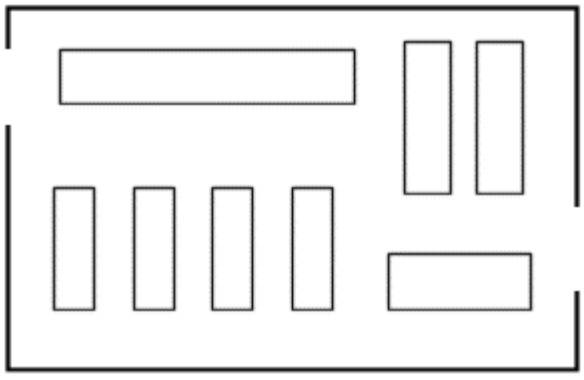
Some customers prefer to "bargain hunt" in off-price stores and do not concern themselves about certain aesthetics. In these stores, a bit of organized clutter actually adds to the "deal" atmosphere. The focus on offering lower-cost merchandise to customers in this way creates a sense of immediacy for the deals. This is a strategy found at such stores as TJ Maxx or Ross Stores.

Whatever your store type, make sure you consider the customer experience in the floor plan. What may make for the most efficient space planning might make for the worst customer experience. A home improvement store, for example, wanted to redesign its space to better showcase its merchandise. Despite having an in-demand selection of goods the store also suffered from terrible merchandising. The tiles section was on one side of the store but the tools and supplies needed for the tile installation were at the opposite end of the store.

This layout created more problems than it solved. It reduced opportunities for impulse purchases by distancing related merchandise from each other. Consumers are more likely to add on purchases by filling their baskets with goods grouped near the main item they need. A layout can create frustration if it forces customers to walk from one side of the store to the other to find related products.

Adopting and adapting are a few basic store layouts can unlock unrealized sales potential.

Straight Floor Plan

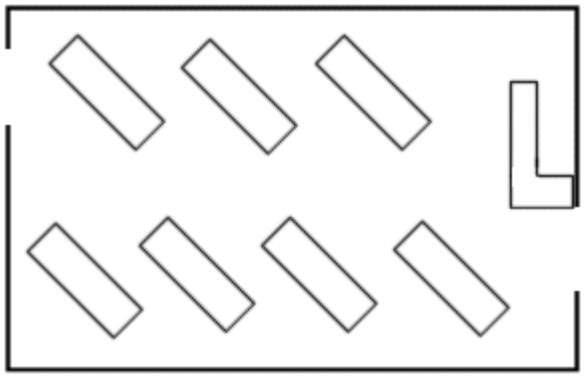


Straight Floor Plan.

The straight floor plan is an excellent store layout for most any type of retail store. It makes use of the walls and fixtures to create small spaces within the retail store. The straight floor plan is one of the most economical store designs.

The downside to this plan is the sight lines in the store. Depending on the front entrance, it may be difficult for a customer to see the variety of merchandise you have. Customers might not quickly find the products they want to purchase.

Diagonal Floor Plan

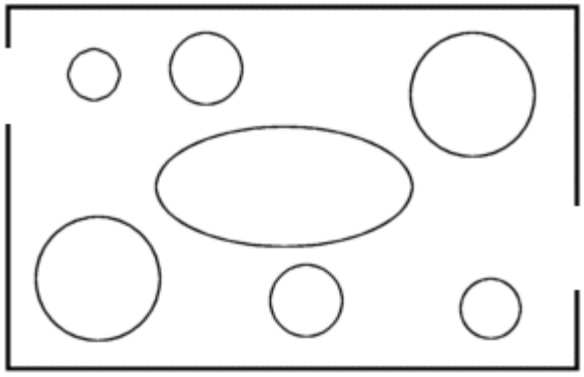


Diagonal Floor Plan.

The diagonal floor plan is a good store layout for self-service types of retail locations. It offers excellent visibility for cashiers and customers. The diagonal floor plan invites movement and traffic flow to the retail store.

This plan is more "customer friendly." Unlike a straight plan, which can feel like a maze, this floor plan offers the customer a more open traffic pattern.

Angular Floor Plan

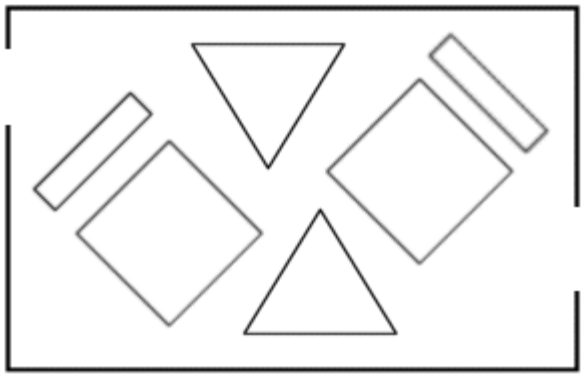


Angular Floor Plan.

The angular floor plan is ideal for high-end specialty stores. The curves and angles of fixtures and walls makes for a more expensive store design. However, the soft angles create better traffic flow throughout the retail store.

This design has the lowest amount of available display space, so it is best for specialty stores who display edited inventories versus large selections.

Geometric Floor Plan

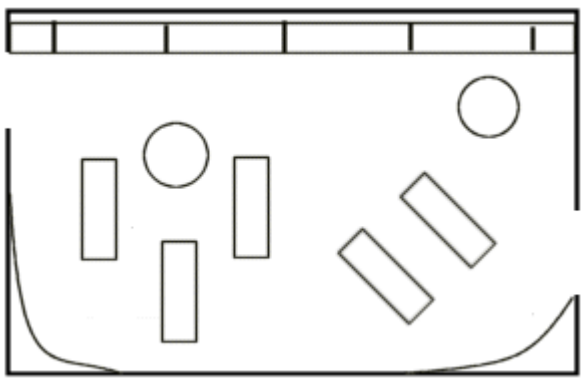


Geometric Floor Plan.

The geometric floor plan is a suitable store design for clothing and apparel shops. It uses racks and fixtures to create an interesting and out-of-the-ordinary type of store design without a high cost.

This plan makes a statement about the products the store sells and the customers it wants to attract. So make that statement speaks to the message you want to associate with your brand.

Mixed Floor Plan



Mixed Floor Plan.

As you might have guessed, the mixed floor plan incorporates the straight, diagonal and angular floor plans to create the most functional store design. The layout moves traffic towards the walls and back of the store.

It is a solid layout for most any type of retailer. Some of the most-admired examples of customer experience can be attributed to stores that have multiple shapes, elevations, and designs. This appeals to a larger array of customers.

INVENTORY CONTROL DEFINITION

At first glance, inventory control and inventory management seem similar. After all, they both cover similar bases revolving around the question, "How much stock should I order?"

Although these two terms are often used interchangeably, they actually deal with different aspects of inventory optimization.

Inventory control involves warehouse management. This includes:

- Barcode scanner integration
- Reorder reports and adjustments
- Product details, histories, and locations
- Comprehensive inventory lists and counts
- Variants, bundles and kitting
- Syncing stock on hand with sales orders and purchase orders

The goal of inventory control procedures is to maximize profits with minimum inventory investment, without impacting customer satisfaction levels

Inventory management, on the other hand, is a broader term that covers how you obtain, store, and profit from raw materials and finished goods alike. The right stock, at the right levels, in the right place, at the right time, at the right cost.

Importance of inventory control

The annoying thing about new inventory control methods is the time and effort required to put them in place. And so it's tempting to just focus on other things – like getting your marketing sorted.

But there are some pretty huge benefits that make taking a firm grip of your inventory management well worthwhile:

- **Increased sales**. With 70% of shoppers choosing a competitor over waiting for backordered items, better inventory management prevents missing out on sales. And it's also much easier to open up new sales channels – especially with automated tools for Shopify inventory management, Magento inventory management and others.
- **Loyal customers**. 65% of buyers have cut ties with a brand over a single poor experience, but great inventory control helps add more value and create loyalty.
- **Reduced storage costs**. Having just the right amount of stock on hand at any one time means you're not overpaying for unnecessary storage.
- **Less waste**. Inventory that doesn't move can eventually become dead or spoilt – meaning a total waste of all kinds of different resources.

Of course – all this means **more cash in the bank** as it's no longer tied up in sitting stock. Cash that can then be put into business growth and expansion.

INVENTORY CONTROL METHODS FOR FORECASTING

Inventory forecasting is an essential part of inventory control. It helps **keep an optimised stock level** – striking a perfect balance between having too much or too little at any one time.

There are three key methods to take note of when it comes to this:

1) Setting a safety stock level

Safety stock is effectively the **backup stock you keep on-hand** for each of your items.

It's about **being prepared** for the unexpected. And it should never be used for normal daily sales as it's reserved purely for sudden increases in demand.

It's always going to be an estimation, but just blind guessing and hoping is risky. It's therefore much better to use **as much past data as possible** in your decision.

That's why we suggest taking a look at your best sales days over the previous quarter or year and inputting into the following formula:

This gives a much more **data-backed method** for maintaining safety stock while still being able to fulfil typical daily sales.

2) Determining reorder points

A reorder point is exactly what it says on the tin – the **exact point** at which ordering new stock needs to happen.

This may sound simple at first. But order too early and you end up overstocked, while too late sees your safety level eaten into.

It's therefore imperative to **take into account the lead time** between ordering new stock and it being delivered and ready for sale. This way, you have a **buffer to still fulfil daily sales** without going into safety stock.

Use the following steps to work out your perfect reorder point for each item:

1. Take the **average number of days** (lead time) between ordering new items and having them ready for sale…
2. Multiply this by your **average daily sales volume** over the past month/quarter/year…
3. And then **add your safety stock** number.

Here it is written out as a simple formula:

3) Economic Order Quantity (EOQ)

Safety stock and reorder point are inventory control methods that help determine **when** to order new stock. But figuring out **how much** to order is a separate conundrum.

Economic Order Quantity helps calculate this while also **keeping carrying costs to a minimum**.

To start with, here are the three variables EOQ is based on:

- **Demand**. The number of units sold over a given time period, usually a year.
- **Relevant ordering cost**. Total ordering cost **per purchase order**. This includes all staff, transportation and any other cost associated with making each order.

- **Relevant carrying cost**. Assume the item is in stock for the entire time period in question and decipher the carrying cost **per unit**.

Once you have these figures, put them into the following formula:

At first glance, this can be a pretty daunting equation. So let's take a look at an example of it in action.

Imagine your business sells trainers and has a demand of **18,000 units per year** (1,500 a month). You've also worked out that staffing and transportation gives a total ordering cost of **£75 per purchase order** while carrying costs sit at **£4 per unit**.

Our formula now turns into this:

Economic Order Quantity = square root of [((2 x 18,000) x £75) ÷ £4]

Economic Order Quantity = square root of [2,700,000 ÷ £4]

Economic Order Quantity = square root of 675,000

Economic Order Quantity = 822

Based on the numbers used above, the perfect order quantity for this specific item would be **822 units per order**.

BIN CARD

Bin card is the statement of all the receipts and issue of the stock from the store department. It is also called stock card or bin tag. It is the responsibility of the store keeper to write every in and out of stock from the store. The physical stock count and the stock quantity reported according to the bin card should be equal; otherwise internal audit department will have the right to investigate the matter with management.

Bin card only contain quantity column for both and receipts and at the close of each transaction, the stock level is calculated to make sure that at every point of time, it can be reconciled with the physical count.

Inventory management is not an easy task. That is why, it is crucial to control the flow of the inventory using some effective tools. One of the best tool to exercise tight control over the inventory is the Bin Card. Not just it helps in controlling the inventory very well, it also helps in maintaning an effective working capital. By knowing the pattern of the stock movement, an entity can easily determine how much capital, it should invest in the purchasing of t he inventory and for how much quantity. As a result, better working capital policies can be developed that will improve the liquidity of the company.

Advantages of Bin Card

As bin card is maintained for each item of inventory, the store keeper is well aware about the stock position. On each bin card, he or she can write the minimum stock and maximum stock level so that in case, any item of inventory is touching minimum level, he or she can create a purchase requisition for the fresh supply of the stock. Bin card is an important inventory control technique and is used in various formats. There is no specific format for the bin card as organization can design their own stock card according to their requirements and reporting analysis.

Bin Card can be maintained in the Excel or can be taken as hard copy print out format that store incharge can use. For your comfort, we are including the Bin Card in the following format:

Bin Card Format

ABC Company

Specimen Bin Card Format

Bin card #: Code #: Material name: Location: Stores ledger folio:	Maximum stock level: Minimum stock level: Recorder level: In charge:

Date	**Receipts**		**Issues**		**Balance**	**Checked & Verified By**		
	G.R.N	Qty	Requisition #	Qty	Qty	Date	Name	Initial

BIN CARD FORMAT

A BIN CARD is a document that records the status of a good held in stock. A typical retailing business with a large stock warehouse will use a BIN card to record a running balance of stock on hand, in addition to information about stock received and notes about problems associated with that stock item.

Business Division :
Business Department :
Business Item Name :
Business Item Code :

No	Date	In	Out	Balance	Notes	Sign

METHODS OF PURCHASING

Some of the methods of purchasing are discussed as follows:

1. Purchasing by Requirement:

This method refers to those goods which are purchased only when needed and in required quantity. The goods which are not regularly required are purchased in this way. On the other hand it refers to the purchase of emergency goods. These goods are not kept in store. Purchasing department must be in knowledge of the suppliers of such goods so that these are purchased without loss of time.

2. Market Purchasing:

Market purchasing refers to buying goods for taking advantages of favourable market situations. Purchases are not made to meet immediate needs but are acquired as per the future requirements. This method will be useful if future needs are estimated accurately and purchases are made whenever favourable market situations arise. The market situation is constantly studied for forecasting price trends.

The advantages of this method are: lower purchase prices, more margin on finished products due to lower material cost and saving in purchase expenses. This method suffers from some limitations: losses in case of wrong judgment, fear of obsolescence, higher storing expenses due to more purchases.

3. Speculative Purchasing:

Speculative purchasing refers to purchases at lower prices with a view to sell them at higher prices in future. The attention in this method is to earn profits out of price rises later on. The purchases are not made as per the production needs of the plant rather these are far in excess of such requirements. A cloth mill may purchase cotton in the market when prices are low with the attention of earning profits out of its sales when prices go up.

Speculative purchasing should not be confused with market purchasing. The former is done to earn profits out of future price rises where as the latter is concerned with purchasing for own needs when favourable market situations exist. Though speculative purchasing may result in profits but there are chances of prices going down in future, fear of obsolescence and incurring higher storage costs.

4. Purchasing for Specific Future Period:
This method is used for the purchase of those goods which are regularly required. These goods are needed in small quantity and chances of price fluctuations are negligible. The needs for specific period are assessed and purchases made accordingly. The requirements for such purchases may be assessed on the basis of past experience, period for which supplies are needed, carrying cost of inventory etc.

5. Contract Purchasing:
In the words of Spriegel it is "the purchasing under contract, usually formal, of needed materials, delivery of which is frequently spread over a period of time." Under this method a specific quantity of materials is contracted to be purchased and delivery is taken in future. Even though the goods are procured in future but the price and other terms and conditions are fixed at the time of contract. This method may be useful when price rises in future may be expected and material requirements for future may be accurately estimated.

6. Scheduled Purchasing:
Under this method the suppliers are supplied a probable time schedule for material requirements so that they are in a position to arrange these in time. An accurate production schedule is prepared for estimating future material needs. The suppliers are informed of probable needs and orders are sent accordingly. The schedule provided by the purchaser to the vendor is not a contract. This is only a gentleman's agreement for terms and conditions of purchases. The main objectives of this method are: minimum inventory, prompt service. low prices, quality goods etc.

7. Group Purchasing of Small Items:
Sometimes a number of small items are required to be purchased. The prices of these items are so small that costs of placing orders may be more than prices. In such situations the buyer places order with a vendor for all these items. The purchase price is agreed to be by adding some percentage of profit in the dealer's cost. This method will be used only when dealer's records are open to inspection for determining his cost. This type of purchasing reduces the cost of the buyer by eliminating much clerical work.

8. Co-operative Purchasing:
Small industrial units may join to pool their requirements and then place bulk orders with dealers. This will help them in availing rebates on large quantity purchases, cash discounts and savings in transportation costs. After receiving the materials these are divided among the member units. Co-operative purchasing helps small units in availing the benefits of bulk purchasing.