DJB3A - PRODUCTION MANAGEMENT

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Reference Books:

1. Production Management ELWOOD BUFFA (JOHNURTON)
2. Manufacturing Management, FRANKLING G. MOORA – (RICHARD IRWIN)
3. Effective Industrial Management – LUNDY (EYRASIA)
4. Production Management – GOEL
5. Introduction to Work Study – I.L.O.
6. Time and Motion Study – BARNER
7. Time and Motion Study – NADLER
8. Motion and Time Study – MANDEL

UNIT-I

Production Management – Definition – Scope – Functions of Production Manager – Factor Governing the choice of Materials – production systems – Job order – Intermittent and continuous Flow Line production – Assembly line production – Automation

INTRODUCTION

Production/operations management is the process, which combines and transforms various resources used in the production/operations subsystem of the organization into value added product/services in a controlled manner as per the policies of the organization. Therefore, it is that part of an organization, which is concerned with the transformation of a range of inputs into the required (products/services) having the requisite quality level.

The set of interrelated management activities, which are involved in manufacturing certain products, is called as **production management**. If the same concept is extended to services management, then the corresponding set of management activities is called as **operations management**.

HISTORICAL EVOLUTION OF PRODUCTION AND OPERATIONS MANAGEMENT

For over two centuries operations and production management has been recognised as an important factor in a country's economic growth. The traditional view of manufacturing management began in eighteenth century when **Adam Smith** recognised the economic benefits of specialisation of labour. He recommended breaking of jobs down into subtasks and recognises workers to specialised tasks in which they would become highly skilled and efficient. In the early twentieth century, F.W. Taylor implemented Smith's theories and developed scientific management. From then till 1930, many techniques were developed prevailing the traditional view. Brief information about the contributions to manufacturing management is shown in the Table 1.1.

TABLE 1.1 Historical summary of operations management

Date	***Contribution***	***Contributor***
1776	Specialization of labour in manufacturing	Adam Smith
1799	Interchangeable parts, cost accounting	Eli Whitney and others

1832	Division of labour by skill; assignment of jobs by skill; basics of time study	Charles Babbage
1900	Scientific management time study and work study developed; dividing planning and doing of work	Frederick W. Taylor
1900	Motion of study of jobs	Frank B. Gilbreth
1901	Scheduling techniques for employees, machines jobs in Manufacturing	Henry L. Gantt
1915	Economic lot sizes for inventory control	F.W. Harris
1927	Human relations; the Hawthorne studies	Elton Mayo
1931	Statistical inference applied to product quality: quality control charts	W.A. Shewart
1935	Statistical sampling applied to quality control: inspection sampling plans	H.F. Dodge & H.G. Roming
1940	Operations research applications in World War II	P.M. Blacker and others.
1946	Digital computer	John Mauchlly and J.P. Eckert
1947	Linear programming	G.B. Dantzig, Williams & others
1950	Mathematical programming, on-linear and stochastic Processes	A. Charnes, W.W. Cooper & others
1951	Commercial digital computer: large-scale computations available.	Sperry Univac
1960	Organizational behaviour: continued study of people at work	L.Cummings, L. Porter
1970	Integrating operations into overall strategy and policy, Computer applications to manufacturing, Scheduling and control, Material requirement planning (MRP)	W. Skinner J. Orlicky and G. Wright
1980	Quality and productivity applications from Japan: robotics, CAD-CAM	W.E. Deming and J. Juran.

Production management becomes the acceptable term from 1930s to 1950s. As F.W. Taylor's works become more widely known, managers developed techniques that focussed on economic efficiency in manufacturing. Workers were studied in great detail to eliminate

wasteful efforts and achieve greater efficiency. At the same time, psychologists, socialists and other social scientists began to study people and human behaviour in the working environment. In addition, economists, mathematicians, and computer socialists contributed newer, more sophisticated analytical approaches.

With the 1970s emerges two distinct changes in our views. The most obvious of these, reflected in the new name **operations management** was a shift in the service and manufacturing sectors of the economy. As service sector became more prominent, the change from 'production' to 'operations' emphasized the broadening of our field to service organizations. The second, more suitable change was the beginning of an emphasis on synthesis, rather than just analysis, in management practices.

System: It consists of elements or components. The elements or components are interlinked together to achieve the objective for which it exists. Eg: human body, educational institutions, business organizations.

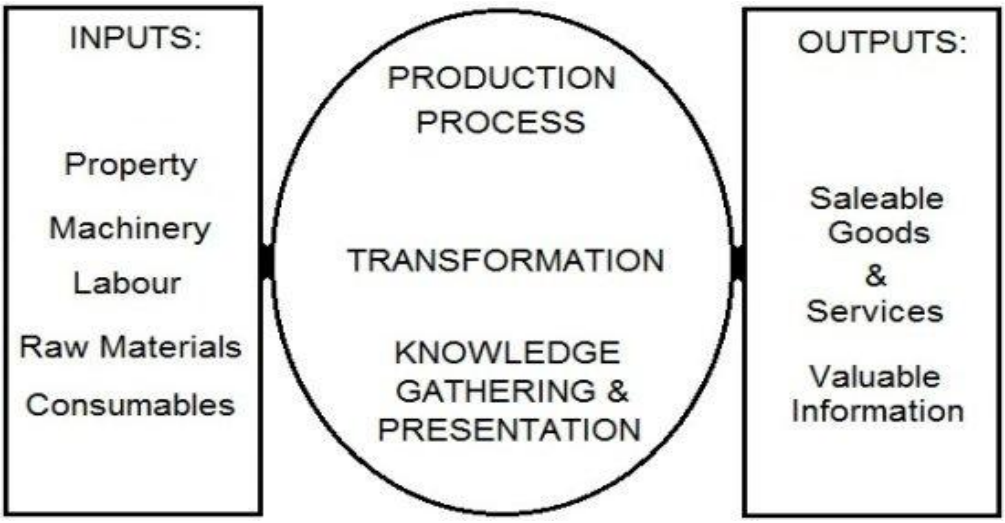


Figure 1.1 Transformation process

Components of a system: The input, processing, output and control of a system are called the components of a system.

Control: There are two types of control, namely Proactive Control and Reactive Control. There are three types of feedback mechanisms such as *feed forward control, feedback control and concurrent control*

DEFINITION:

In any manufacturing system, the job of a Production Manager is to manage the process of converting inputs into the desired outputs.

- *It is concerned with the production of goods and services, and involves the responsibility of ensuring that business operations are efficient and effective.*
- *It is also the management of resources, the distribution of goods and services to customers.*
- The performance of the management activities with regards to selecting, designing, operating, Controlling and updating production system.
- It is the processes of effectively planning, coordinating and controlling the production, that is the operations of that part of an enterprise, it means to say that production and operations Management is responsible for the actual transformation of raw materials into finished products.
- Production management is a function of Management, related to planning, coordinating and controlling the resources required for production to produce specified product by specified methods, by optimal utilization of resources.
- Production management is defined as management function which plans, organizes, co-ordinates, directs and controls the material supply and Processing activities of an enterprise, so that specified products are produced by specified methods to meet an approved sales programme. These activities are being carried out in such a manner that Labour, Plant and Capital available are used to the best advantage of the organization.

Therefore, **Production Management** can be defined as the management of the conversion process, which converts land, labor, capital, and management inputs into desired outputs of goods and services. It is also concerned with the design and the operation of systems for manufacture, transport, supply or service.

DIFFERENCE BETWEEN OPERATIONS AND PRODUCTION

In the transformation process, the inputs change the form into an output, by adding value to the entity.

The output may be a product or service.

- If it is a product centric that is known as **production**,
- If it is a service centric then that is known as **operation**.

PRODUCTION SYSTEM

A production system is a collection of people, equipment, and procedures organized to perform the manufacturing operations of a company (or other organization)

COMPONENTS OF A PRODUCTION SYSTEM:

There are two components for a production system such as:

1. **Facilities** – the factory and equipment in the facility and the way the facility is organized (plant layout)
2. **Manufacturing support systems** – the set of procedures used by a company to manage production and to solve technical and logistics problems in ordering materials, moving work through the factory, and ensuring that products meet quality standards

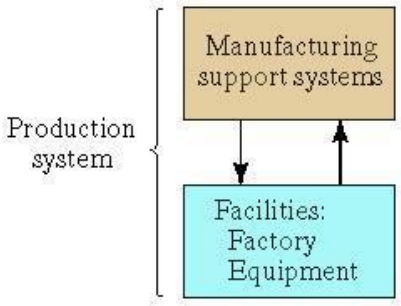


Figure 1.2 Diagrammatic representation for a production system

Facilities include the factory, production machines and tooling, material handling equipment, inspection equipment, and computer systems that control the manufacturing operations. For the facilities, plant layout is a significant factor for the production system to be efficient. The plant layout is the way in which the equipment is physically arranged in the factory.

Manufacturing systems include the logical groupings of equipment and workers in the factory. A combination of a group of workers and machines are termed as Production line. There can be instances where there is only one worker and a machine. This arrangement is called as Stand-alone workstation and worker. Based on the human participation in the production processes, the manufacturing system can be classified as the following three systems:

- ***Manual work systems*** - a worker performing one or more tasks without the aid of powered tools, but sometimes using hand tools. *For example*, filing work carried out in the central workshop

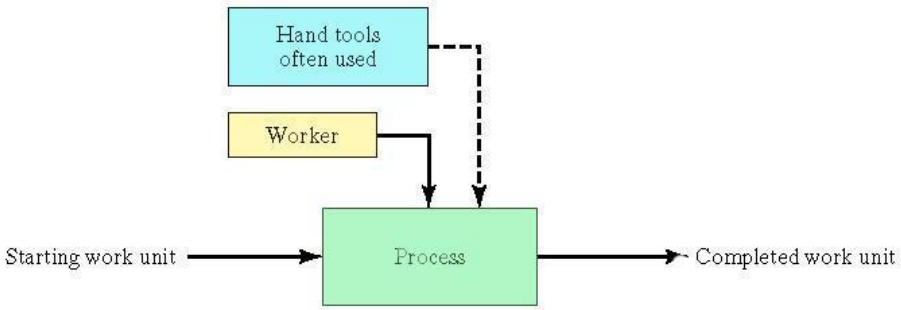


Figure 1.3a Diagrammatic representation a manual work system

- ***Worker-machine systems*** - a worker operating powered equipment. *For example,* turning done on a work piece using a Lathe.

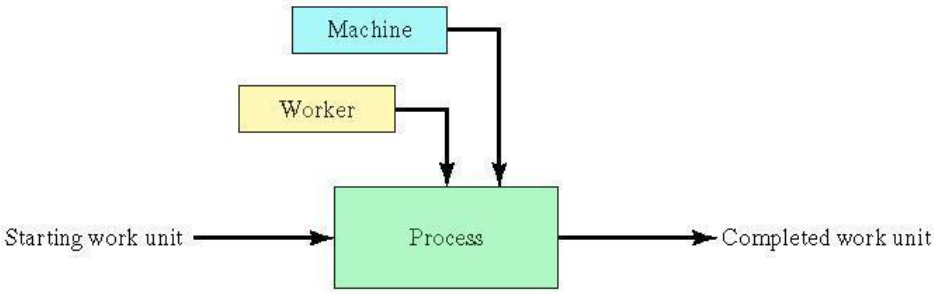


Figure 1.3b Diagrammatic representation a worker-machine system

- ***Automated systems*** - a process performed by a machine without direct participation of a human *For example,* turning done on a work piece using a CNC machine.

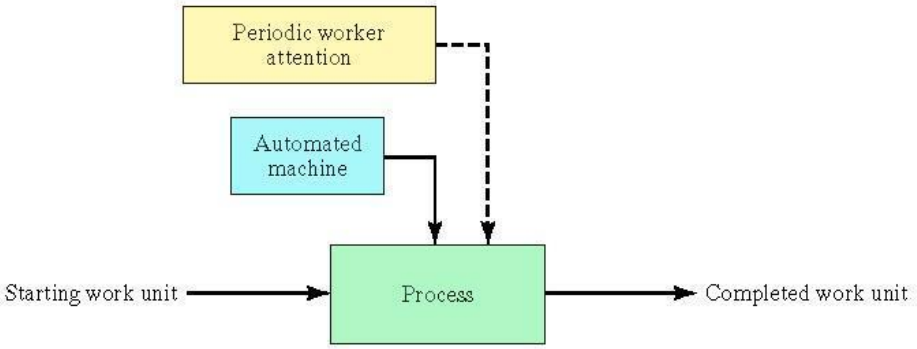


Figure 1.3c Diagrammatic representation an automated system

Types of Production Process

There are mainly three types of production systems or production process. They are discussed briefly below:

1. Continuous System
2. Intermittent System
3. Project systems

1. Continuous System

Continuous production refers to the manufacturing of large volume of a single or a very few varieties of products with a standard set of processes. The mass production is carried on continuously for stock in anticipation of demand.

Features of the continuous production are given below:

1. The volume of output is generally large.
2. The product design and the operations stages are standardised
3. Special purpose automatic machines are used to perform standardised operations.
4. Product layout is designed according to a separate line for each product.

Merits of continuous production process

The following are the advantage of continuous production system:

1. The main advantage of continuous production system is that work-in-progress inventory is minimal.
2. The quality of output is kept uniform because each stage develops skills of employees through repetition of work.
3. Any delay at any stage is automatically detected.
4. Handling of materials is reduced due to the set pattern of production line
5. Control over materials, cost and output is simplified.
6. The work can be done by semi-skilled workers because of their specialization.

Demerits of continuous production system:

1. Strict maintenance is necessary to avoid production hold ups.
2. Huge capital investment is required.
3. Cannot make sudden changes in the production system.

Types of continuous production system:

1.1. Mass Production

In this method, a few types of products are manufactured in large quantities. The volumes are high and products are standardised which allows resources to be organised around particular products. Mass Production is characterised by the following features:

1. Standard products are manufactured.

2. Standardised inputs and standardised operations are used for manufacturing.
3. Large volume of products.
4. Shorter cycle time of production.
5. Less supervision is required.
6. Perfectly balanced production lines.
7. Flow of materials, components and parts are continuous
8. Production planning and control are easy.

Advantages of mass production

Following are the advantages of Mass Production:

1. Higher rate of production with reduced cycle time.
2. Higher capacity utilisation.
3. Less skilled operators can also be employed.
4. Low process inventory.
5. Manufacturing cost per unit is low.

Limitation of mass production

Following are the limitations of Mass Production:

1. Breakdown of one machine will stop entire production line.
2. Line layout needs major change with the changes in the product design.
3. High investment in production facilities is required.

1.2. Process Productions

Production facilities are arranged as per the sequence of production operations from the first operations to the finished product. It involves continuous physical flow of material from one stage to another stage. The process usually operates round the clock to maximise utilisation and to avoid expensive shutdowns and start-ups.

Characteristics of process production

Process Production is characterised by:

1. Material handling is fully automated.
2. Process follows a predetermined sequence of operations.
3. It is used for bulk manufacturing.
4. Planning and scheduling is a routine action.

Advantages

Following are the advantages of process Production:

1. Standardisation of product and process sequence.
2. Higher rate of production with reduced cycle time.
3. Higher capacity utilisation due to line balancing.
4. Manpower is not required for material handling as it is completely automatic.
5. Person with limited skills can be used on the production line.
6. Unit cost is lower due to high volume of production.

Limitations

Following are the limitations of process Production.

1. Flexibility to accommodate and process number of products does not exist.
2. Very high investment for setting flow lines.

2. Intermittent Production System

In this system, the goods are generally produced to fulfill customers' orders rather than producing against stock. Intermittent situations are those where the facilities must be flexible enough to handle a variety of products and sizes. The flow of material is intermittent. The production facilities are flexible enough to handle a wide variety of products and sizes. In the industries following the intermittent production system, some components may be made for inventory but they are combined differently for different customers. The finished product is heterogeneous but within a range of standardized options assembled by the producers. Since production is partly for stock and partly for consumer demand, there are problems to be faced in scheduling, forecasting, control and coordination.

Characteristics intermittent production

The Characteristics intermittent production is given below:

1. The flow of production is intermittent, not continuous.
2. The volume of production is generally small.
3. A wide variety of products are manufactured.
4. General purpose machines and equipment are used.
5. No single sequence of operations is used for a long period.
6. Process layout is most suited in a highly competitive environment.
7. Periodical adjustments are made to suit different jobs or batches.

Intermittent system is much more complex than continuous production system because every product has to be treated differently. Intermittent system can be effective in situations which satisfy the following conditions:

1. The production centres should be located in such a manner so that they can handle a wide range of inputs.
2. Transportation facilities between production centres should be flexible.
3. It should be provided with necessary storage facility.

Types of Intermittent Production

Basically there are two types of intermittent production system. They are as follows:

2.1. Job Production

In the case of Job production, the products are manufactured as per the specifications of the customers within pre -determined time and cost. The main feature of this method is low volume and high variety of products compared to mass production. Under this method, each job demands unique production activities.

Features of job production

The following are the features of job production system:

1. More variety of products is manufactured as per customer'srequirements.
2. Volume of production is low.
3. Highly skilled employees are required to do the work.
4. Detailed planning is essential for sequencing the requirements of each product.

5.Employees should be able to take each job as a challenge.

Advantages

Advantages of job production are as follows:

1. It tries to satisfy the unique requirements of customers.
2. Employees will become more skilled, as each job gives them learning opportunities to develop.
3. Full potential of employees can be utilised.
4. Opportunity exists for employees to do creative works.

Limitations

Following are the limitations of Job Production system:

1. Higher cost due to frequent set up changes.
2. It results in higher level of inventory at all levels and also higher inventory cost.
3. Production planning is complicated.
4. Larger space requirement is needed.

2.2. Batch Production

Under batch production method, items are processed in lots or batches and a new batch is undertaken for production only when the production on all items of a bath is complete. In fact, batch type of production system can be considered as an extension of job type system.

Characteristics of batch production

Batch Production is characterised by

1. Shorter production runs.
2. Products are manufactured in small batches.
3. Plant and machinery set up is used for the production of item in a batch and change of set up is required for processing the next batch.
4. Manufacturing lead-time and cost are lower as compared to job order production.

Advantages

Following are the advantages of Batch Production:

1. Better utilisation of plant and machinery facilities.
2. It promotes functional specialisation.
3. Cost per unit is lower as compared to job order production.
4. Lower investment in plant and machinery is required.

Limitations

Following are the limitations of Batch Production:

1. Material handling is complex because of irregular and longer flows.
2. Production planning and control are complex.
3. Higher set up costs due to frequent changes in set up.

PRODUCTION MANAGEMENT

Production management is a process of planning, organizing, directing and controlling the activities of the production function. It combines and transforms various

resources used in the production subsystem of the organization into value added product in a controlled manner as per the policies of the organization.

E.S. Buffa defines production management as, **"Production management** *deals with decision making related to production processes so that the resulting goods or services are produced according to specifications, in the amount and by the schedule demanded and out of minimum cost.*"

Objectives of Production Management

The objective of the production management is 'to produce goods services of right quality and quantity at the right time and right manufacturing cost'.

9. RIGHT QUALITY

The quality of product is established based upon the customers needs. The right quality is not necessarily best quality. It is determined by the cost of the product and the technical characteristics as suited to the specific requirements.

2. RIGHT QUANTITY

The manufacturing organization should produce the products in right number. If they are produced in excess of demand the capital will block up in the form of inventory and if the quantity is produced in short of demand, leads to shortage of products.

3. RIGHT TIME

Timeliness of delivery is one of the important parameter to judge the effectiveness of production department. So, the production department has to make the optimal utilization of input resources to achieve its objective.

4. RIGHT MANUFACTURING COST

Manufacturing costs are established before the product is actually manufactured. Hence, all attempts should be made to produce the products at pre-established cost, so as to reduce the variation between actual and the standard (pre-established) cost.

SCOPE OF PRODUCTION AND OPERATIONS MANAGEMENT

Production and operations management concern with the conversion of inputs into outputs, using physical resources, so as to provide the desired utilities to the customer while

meeting the other organizational objectives of effectiveness, efficiency and adoptability. It distinguishes itself from other functions such as personnel, marketing, finance, etc., by its primary concern for 'conversion by using physical resources.' Following are the activities which are listed under production and operations management functions:

1. Location of facilities
2. Plant layouts and material handling
3. Product design
4. Process design
5. Production and planning control
6. Quality control
7. Materials management
8. Maintenance management.

(*i*) Product: Manufacturing system often produces standardized products in large volumes. The plant and machinery have a finite capacity. The facilities constitute fixed costs, which are allocated to the products produced. Variable costs, such as, labour cost and materials costs. While manufacturing the product use value and economic values are added to the product. Hence the product is a store of values added during manufacture. Because the input costs and output costs are measurable, the productivity can be measured with certain degree of accuracy. Product can be transported to the markets and stored physically until it is sold.

(*ii*) Service: Service system present more uncertainty with respect to capacity and costs. Services are produced and consumed in the presence of the customer. We cannot store the service physically. Because of this the service organizations, such as Hotels, Hospitals, Transport Organizations and many other service organizations the capacity must be sufficiently or consciously managed to accommodate a highly variable demand. Sometimes services like legal practice and medical practice involve Professional or intellectual judgments, which cannot be easily standardized. Because of this the calculation of cost and productivity is difficult.

(*iii*) Project: Project system does not produce standardized products. The Plant, Machinery, Men and Materials are often brought to project site and the project is completed. The project is of big size and remains in the site itself after completion. As the costs can be calculated and allocated to the project with considerable accuracy, Productivity can be measured. Once the project is completed, all the resources are removed from site.

FUNCTIONS OF PRODUCTION MANAGEMENT DEPARTMENT

The functions of Production Management depend upon the size of the firm. In small firms the production Manager may have to look after production planning and control along with Personnel, Marketing, Finance and Purchase functions. In medium sized firms, there may be separate managers for Personnel, marketing and Finance functions. But the production planning and control and Purchase and stores may be under the control of Production management department. In large sized firms the activities of Production Management is confined to the management of production activities only. As such, there are no hard and fast rule or guidelines to specify the function of Production Management, but in the academic interest we can mention some of the functions, which are looked after by the Production Management department. They are:

(*i*) Materials: The selection of materials for the product. Production manager must have sound Knowledge of materials and their properties, so that he can select appropriate materials for his product. Research on materials is necessary to find alternatives to satisfy the changing needs of the design in the product and availability of material resumes.

(*ii*) Methods: Finding the best method for the process, to search for the methods to suit the available resources, identifying the sequence of process are some of the activities of Production Management.

(*iii*) Machines and Equipment: Selection of suitable machinery for the process desired, designing the maintenance policy and design of layout of machines are taken care of by the Production Management department.

(*iv*) Estimating: To fix up the Production targets and delivery dates and to keep the production costs at minimum, production management department does a thorough estimation of Production times and production costs. In competitive situation this will help the management to decide what should be done in arresting the costs at desired level.

(*v*) Loading and Scheduling: The Production Management department has to draw the time table for various production activities, specifying when to start and when to finish the process required. It also has to draw the timings of materials movement and plan the activities of manpower. The scheduling is to be done keeping in mind the loads on hand and capacities of facilities available.

(*vi*) Routing: This is the most important function of Production Management department. The Routing consists of fixing the flow lines for various raw materials, components etc., from

the stores to the packing of finished product, so that all concerned knows what exactly is happening on the shop floor.

(*vii*) Despatching: The Production Management department has to prepare various documents such as Job Cards, Route sheets, Move Cards, Inspection Cards for each and every component of the product. These are prepared in a set of five copies. These documents are to be released from Production Management department to give green signal for starting the production. The activities of the shop floor will follow the instructions given in these documents. Activity of releasing the document is known as dispatching.

(*viii*) Expediting or Follow up: Once the documents are dispatched, the management wants to know whether the activities are being carried out as per the plans or not. Expediting engineers go round the production floor along with the plans, compare the actual with the plan and feed back the progress of the work to the management. This will help the management to evaluate the plans.

(*ix*) Inspection: Here inspection is generally concerned with the inspection activities during production, but a separate quality control department does the quality inspection, which is not under the control of Production Management. This is true because, if the quality inspection is given to production Management, then there is a chance of qualifying the defective products also. For example Teaching and examining of students is given to the same person, then there is a possibility of passing all the students in the first grade. To avoid this situation an external person does correction of answer scripts, so that the quality of answers are correctly judged.

(*x*) Evaluation: The Production department must evaluate itself and its contribution in fulfilling the corporate objectives and the departmental objectives. This is necessary for setting up the standards for future. What ever may be the size of the firm; Production management department alone must do Routing, Scheduling, Loading, Dispatching and expediting. This is because this department knows very well regarding materials, Methods, and available resources etc. If the firms are small, all the above-mentioned functions (*i* to *x*) are to be carried out by Production Management Department. In medium sized firms in addition to Routing, Scheduling and Loading, Dispatching and expediting, some more functions like Methods, Machines may be under the control of Production Management Department. In large firms, there will be Separate departments for Methods, Machines, Materials and others but routing, loading and scheduling are the sole functions of Production Management. All the above ten functions are categorized in three stage, that is Preplanning, Planning and control stages .

FACTORS GOVERNING THE MATERIALS SELECTION

The Material Selection Problem

Design of an engineering component involves three interrelated problems:

(i) selecting a material,

(ii) specifying a shape, and

(iii) choosing a manufacturing process.

Getting this selection right the first time by selecting the optimal combination your design has enormous benefits to any engineering-based business. It leads to lower product costs, faster time-to-market, a reduction in the number of in-service failures and, sometimes, significant advantages relative to your competition.

But to realize these benefits, engineers have to deal with an extremely complex problem. There are literally tens of thousands of materials and hundreds of manufacturing processes. No engineer can expect to know more than a small subset of this ever-growing body of information. Furthermore, there are demanding and shifting design requirements such as cost, performance, safety, risk and aesthetics, as well as environmental impact and recycle-ability. This document is meant to provide an introduction to the material selection process.

Material Selection

The basic question is how do we go about selecting a material for a given part? This may seem like a very complicated process until we realize than we are often restrained by choices we have already made. For example, if different parts have to interact then material choice becomes limited.

When we talk about choosing materials for a component, we take into account many different factors. These factors can be broken down into the following areas.

Material Properties

The expected level of performance from the material

Material Cost and Availability

Material must be priced appropriately (not cheap but right)

Material must be available (better to have multiple sources)

Processing

Must consider how to make the part, for example:

Casting

Machining

Welding

Environment

The effect that the service environment has on the part

The effect the part has on the environment

The effect that processing has on the environment

General steps in materials selection

(i) Analysis of the performance requirements.

(ii) Development of alternative solutions to the problem.

(iii) Evaluation of the different solutions.

(iv) Decision on the optimum solution.

Analysis of material performance requirements

The material performance requirements can be divided into 5 broad categories:

- Functional requirements
- Processability requirements
- Cost
- Reliability requirements
- Resistance to service conditions

PRODUCTION ORDERS

Objectives

The objectives are:

- Examine the structure and makeup of a production order
- Review the purpose of a production order
- Define the five statuses of a production order
- Create a new production order
- View the routing and components of a production order
- Reserve components for a production order
- View actual against expected costs, and capacity of a production order
- Make changes to the production order due date
- Make changes to the production order quantity required
- Make changes to the production order components required
- Use item substitution for components

- Make changes to the production order routing
- Examine the reports printed directly from a production order
- Access the Production Schedule from a production order
- Review the standard reports available for production order reporting
- Review the purpose of the Replan Production Order batch job
- Examine how the Replan Production Order batch job operates
- Explain the effects of scheduling a production order with a phantom BOM
- Calculate a manufacturing batch unit of measure
- Identify the two methods of changing the status of a production order

Production orders are used to manage the conversion of purchased materials into manufactured items. Production orders (job or work orders) route work through various facilities (work or machine centers) on the shop floor.

Production Order Status

A production order can have one of the following status codes:

a. Simulated

b. Planned

c. Firm Planned

d. Released

e. Finished

PRODUCTION ORDER TYPES:

1.Simulated Production Order - SPO

The Simulated Production Order (SPO) is the only production order and is unique based on the following characteristics:

- It is not real.
- It does not influence order planning.

2. Planned Production Order - PPO

The Planned Production Order (PPO) is unique because of the following characteristics:

- PPOs affect capacity requirements.
- PPOs serve as good workload estimates.
- PPOs need careful planning.

3.Firm Planned Production Order - FPPO

The Firm Planned Production Order (FPPO)s unique by the following characteristics:

- FPPOs can be manually changed.
- FPPOs are placeholders.
- FPPOs are created from planning, manual creation, or sales orders.
- FPPO creation results in a “planned order release.”

4.Released Production Order - RPO

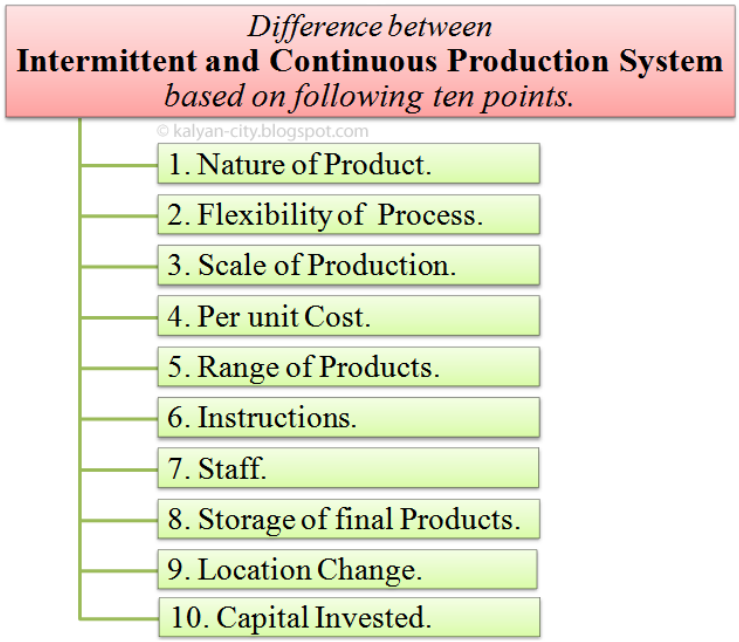
The Released Production Order (RPO is unique by the following characteristics:

- RPOs do not indicate product removal.
- RPOs are not always created immediately after a sales order.
- RPOs can record material consumption from a product output.

5.Finished Production Order - FPO

The Finished Production Order (FPO is unique by the following characteristics:

- FPOs are terminal. An FPO is an order that, for some reason, has been terminated. Usually, the order has been manufactured.
- FPOs can track back to other orders. FPOs are used for statistical reporting and to maintain the ability to track back to other orders (sales, production, and purchase, for example).
- FPOs can never be changed. The ability to track back to a finished production order allows you to review the detailed history.



UNIT-II

Plant Location – Factors affecting plant Location – Multiplant Location decision – Plant Layout – Principles, Methods of laying out. Types of layout – product – process and combination layout.

FACILITY OR PLANT LOCATION

Facility location decision is the systematic process of determining a geographic site for a firm's operations. Managers of both service and manufacturing organizations should consider the desirability of a particular site, including proximity to customers and suppliers, labour costs, and transportation costs. Location conditions are difficult to measure. Tangible cost based factors such as wages and products costs can be quantified easily. On the other hand non-tangible features, which refer to such characteristics as reliability, availability and security, cannot be measured exactly in quantitative forms.

Steps in site Selection

The following are the different stages involved in the site selection process:

1. Selection of the region in which the plant is to be established
2. After selecting the region, the next step is to select a locality with in the region.
3. Selection of site for plant construction
4. Final investment decision

There are mainly two sets of factors affecting the location decision:

- General locational factors, which include controllable and uncontrollable factors for all type of organisations.
- Specific locational factors specifically required for manufacturing and service organisations.

Following are the general factors required for location of plant in case of all types of organisations.

1. Proximity to markets
2. Supply of materials
3. Transportation facilities
4. Infrastructure availability

5. Labour and wages
6. External economies
7. Capital.
8. Government policy
9. Climate conditions
10. Supporting industries and services
11. Community and labour attitudes
12. Community Infrastructure.

Controllable factors

1. Proximity to markets

Every company is expected to serve its customers by providing goods and services at the reasonable price and time.Organizations may choose to locate facilities near to the market. When the buyers are concentrated, it is advisable to locate the facilities close to the market. Nearness to the market ensures a consistent supply of goods to customers and it reduces the cost of transportation.

Locating nearer to the market is preferred if:

- The products are subject to spoilage.
- After sales services are promptly required veryoften.

2. Supply of raw material

It is essential for the organization to get right type of raw materialsat the right time in order to have a continuous production. This factor becomes very important if the materials are perishable and cost of transportation is very high. Nearness to raw material is important in case of industries such as sugar, cement, jute and cotton textiles.The following things are to be considered in this case:

- When a single raw material is used without loss of weight, locate the plant at the rawmaterial source or at the market place.

- When weight loosing raw material is required, locate the plant at the raw material source itself.
- When raw material is universally available, locate close to the market area.

3. Transportation facilities

Speedy transport facilities ensure timely supply of raw materials to the production centres. The transport facility is a prerequisite forthe location of the plant. There are different modes of transportation such as, air, road, rail, water and pipeline. Goods that are mainly intended for exports demand, a location near to the port is useful and economical. The factors influencing the choice locational facility includecosts, convenience, and suitability.

4. Availability of infrastructure facilities

The infrastructure facilities like power, water and waste disposal etc., are the important factors in deciding the location facility. Certain types of industries use more amount of power and such company's should be located close to the power station. The non-availability of power may become a survival problem for such industries. Process industries like paper, chemical, cement etc. require continuous supply of water in large amount. Availability of waste disposal facility for process industries is an important factor in modern times.

5. Labour and wages

The problem of securing adequate number of skilled and unskilledwork force is a major factor to be considered at the time site selection. Importing labour is usually costly and involves administrative problems. Productivity of labour is also an important factor to be considered. Prevailing wage pattern, quality of human resources in terms of education, cost of living, industrial relation and bargaining power of the unions' form important considerations.

6. External economies of scale

Availability of various external economies of scale is major factor in deciding the project location. Tax incentives, facility of industrial estates, special economic zone are some of the factors to be considered at the time of taking location decision. Location economies of scale in the manufacturing sector have evolved over time and have mainly increased competition due to production facilities and lower production costs as a result of lower transportation and logistical costs.

7. Availability of Capital

Another important factor deciding the choice of location is the availability of capital. Fixed capital is required for the construction of building and acquisition of land. But on the other hand buildings can also be rented and existing plants can be expanded. The availability

of such factors is also affecting the decision on site selection.A careful study on financial strength and weaknesses of the proposed project should be undertaken.

8. Policies of the Government

The policies of the Central, state governments and local bodies concerning labour laws, building codes, safety, tax etc. are the major factors which affect the choice location for the industries. Government provides various kinds of incentives to entrepreneurs for industrial development in special economic zone. The incentive package may be in the form of exemption from a sales tax and excise duties for a specific period, soft loan from financial institutions and investment subsidy. Some of these incentives may tempt to locate the plant to avail these facilities offered.

9. Climatic conditions

The natural condition of the geographical area needs to be considered together with climatic conditions. Climates greatly influence human efficiency and behaviour and reflect the same in the labour productivity. Some industries require specific climatic conditions e.g., textile mill requireshumidity. Therefore such special climatic factors have to be carefully examined in the choice of project site.

10. Supporting industries and services

Availability of supporting industries is another consideration which affects the choice of location. Manufacturing organisation will not make all the components and parts by itself .Sometimes it subcontracts the work to vendors to manufacture. So,the source of supply of component parts will be the one of the factors that influences the location. The presence of healthy relationship among different firms is also a pre-requisite for industries to develop. The various services like communications, banking services, professional consultancy services will play a vital role in selection of a location.

11. Community and labour attitudes

The general attitude of the community towards proposed industry will have an important bearing in the choice location.Sometimes,a specific location is not desirable because of labours negative attitude towards management, which brings very often the strikes and lockouts. Such conditions have to be seriously analysed.

12. Availability of Community infrastructure

All manufacturing activities require access to a transport infrastructure such as roads, railways, port, power lines and other service facilities .The availability of social facilities like schools, universities and hospitals are also the major determinants in the choice project site. These factors are also required to be considered by managers.

PLANT LOCATION DECISIONS

Before getting into location decisions, it will be helpful for you to understand the terms related to plant location decisions. Plant means any set-up, for the purpose of business, which is engaged in any kind of production operation and yields semi-finished or finished goods as end results. Location, on the other hand, means any place or region of any set-up or concern in which the set-up or concern is situated. Thus plant location decisions are those, made by managers, which are aimed to the selection of a location for the settlement of any intended plant of the concern business. Plant Location decisions are usually based on factors as labor supply condition, raw materials supply condition, distance with the market place, and a lot of others of this type.

Objective of Location Decisions

As a general rule, profit-oriented organizations base their decisions on profit potential, whereas nonprofit organizations strive to achieve a balance between cost and the level of consumer service they provide. It would seem to follow that all organizations attempt to identify the best location available. However, this is not necessarily the case. In many instances, no single location may be significantly better than the others. There may be numerous acceptable locations from which to choose, as shown by the wide variety of locations where successful organizations can be found. Furthermore, the number of location that would have to be examined to find the best location may be too large to make an exhaustive search practical. Consequently, most organizations do not set out with the intention of identifying the one best location; rather, they hope to find a number of acceptable locations from which to choose – and to avoid choosing a location that will create future problems.

Importance of Location Decisions

There are two primary reasons that location decisions are a highly important part of production system design.

- One is that they entail a long-term commitment, which makes mistakes difficult to overcome.
- The other is that location decisions often have an impact on investment requirements, operating costs and revenues, and operations itself.

For instance a poor choice of location might result in excessive transportation costs, a shortage of qualified labor, loss of competitive advantage, inadequate supplies of raw

materials, or some similar condition that is detrimental to operations. For services, a poor location could result in loss of customers and/or high operating costs.

Phases of Plant Location Theory

The problem of plant location can be defined as the determination of that location which, when confederating all factors, will provide minimum delivered-to-customer cost of the product(s) to be manufactured. Plant location theory can be considered to have passed though four phases:

1. The Least Production Cost Site phase: In this phase interests were concentrated on location factors directly affecting cost of production.

2. The Nearness of Market phase. In this phase more realistic concepts are introduced, such as the effect of uneven population, uneven resource distribution, imperfect competition and the independence of firms within a multi-market economy.
3. The Profit Maximization phase. This phase stressed that the firm's optimum location was determined by the difference between total revenue and total cost.
4. The Least Costs to Customer phase. This is similar to the profit maximization phase, but decision data were related to delivered costs to customers. Greater emphasis is given on analytical models, such as linear programming models and delivery time to customers.

PLANT/FACTORY LAY OUT

Plant layout refers to the physical arrangement of production facilities. It is the configuration of departments, work centres and equipment in the conversion process. It is a floor plan of the physical facilities. There are several factors which affect the choice of factory layout.

Definition of plant layout

According to Moore 'Plant layout is a plan of an optimum arrangement of facilities including personnel, operating equipment, storage space, material handling equipment and all other supporting services along with the design of best structure to contain all these facilities'.

OBJECTIVES OF LAY OUT

The basic objective of the plant layout is to arrange production facilities economically. The objectives of plant layout are given below:

1. Streamline the flow of materials through the plant.

2. Facilitate the manufacturing process.
3. Minimise materials handling cost.
4. Effective utilisation of men, equipment and space.
5. Flexibility of manufacturing operations and arrangements.
6. Provide for employee convenience, safety and comfort.
7. Minimize investment in equipment

PRINCIPLES OF LAY OUT

The following are the principles plant layout:

1. Principle of integration

A good layout is one that integrates men, materials, machines and supporting services and others in order to get the optimum utilisation of resources and maximum effectiveness at least cost.

2. Principle of minimum distance

This is concerned with the minimum movement of man and materials. The facilities should be arranged such a way that, the total distance travelled by the men and materials should be minimum. As far as possible straight line movement should be preferred.

3. Principle of cubic space utilisation

The good layout is one that utilise both horizontal and vertical space. It is not only enough if only the floor space is utilised optimally but the third dimension, i.e., the height is also to be utilised effectively.

4. Principle of flow

A good layout is one that makes the materials to move in forward direction towards the completion stage. This means there should not be any backtracking.

5. Principle of maximum flexibility

The good layout is one that can be altered without much cost and time

.The future requirements should be taken into account while designing the present layout of the plant.

6. Principle of safety, security and satisfaction

A good layout is one that gives due consideration to workers safety and satisfaction and safeguards the plant and machinery against fire, theft, etc.

7. Principle of minimum handling

A good layout is one that reduces the material handling.

Factors to be considered in plant lay out

The following are the important factors to be considered at the time of plant lay out. They are given below;

1. Need for plant expansion

The future requirements of the organisation should be considered at the time of planning for plant location.

2. Protection of operation equipment

Every care should be taken to ensure the safety machinery and equipment. Shelter is required whenever there is need to protect equipment from adverse climatic conditions.

3. Maintenance requirements

Some equipment's require continuous maintenance .There should be adequate facilities in maintain the equipment's and machinery. This requirement has to be considered at the time of planning plant layout.

4. Location

The site selected for the plant also determines the plant lay out. The structure, geology, climatic conditions of the location influence the decision on plant layout.

TYPES OF LAY OUT

Layouts can be classified into the following five categories:

1. Process layout
2. Product layout
3. Combination layout
4. Fixed position layout
5. Group layout

PROCESS LAY OUT

In the case of process lay out all the machines performing similar type of operations are grouped at one location. In process layout the arrangement of facilities is grouped

together according to their functions and operations. The flow of material through the facilities from one functional area to another functional area varies from product to product. Process layout is suggested for batch production. Usually the paths are long and there will be possibility of backtracking.Process layout is normally used when the production volume is not sufficient to justify a product layout.

Advantages of process layout

Advantages of process layout are as follows:

1. In process layout machines are better utilized.
2. Flexibility is possible in process layout.
3. Lower investment on account of comparatively less number of machines
4. Higher utilisation of production facilities.
5. A high degree of flexibility with regards to work distribution to machineries and workers.
6. The diversity of tasks and variety of job makes the job interesting.
7. Supervisors will become highly knowledgeable about the functions under their department.

Limitations of process layout

1. Backtracking of materials.
2. Material handling cannot be mechanised which adds to cost.
3. Lower productivity due to number of set-ups.
4. Space and capital are tied up by work-in-process
5. Long movements may occur in the handling of materials thus reducing material handling efficiency.

Product layout

In product layout, machines and other supporting services are located according to the processing sequence of the product. It implies that various operations on a product are performed in a sequence and the machines are placed along the product flow line .In product layout machines are arranged in the sequence in which a given product will be operated upon. This type of layout is preferred for continuous production of goods.

Advantages of product lay out

1. The flow of product will be smooth.
2. Work -in-process inventory is less.
3. Processing time is less.
4. Minimum material handling cost.

5. Simplified production, planning and control systems are possible.
6. Less space is occupied by work transit and for temporary storage.
7. Reduced material handling cost due to mechanised handling systems.
8. Perfect line balancing which eliminates all bottlenecks.
9. Manufacturing cycle is short due to continuous flow of materials.
10. Small amount of work-in-process inventory.
11. Unskilled workers can manage the production.

Limitations

1. A breakdown of one machine in a product line may cause stoppages of machines in the downstream of the line.
2. A change in product design may require major alterations in the layout.
3. Comparatively high investment in equipment's is required.
4. Lack of flexibility.
5. A change in product may require the facility modification

Combination lay out

A combination layout combines the advantages of both types of product and process layouts. A combination layout is possible where an item is being made in different types and sizes. Here machinery is arranged in a process layout but the process grouping is then arranged in a sequence to produce various types and sizes of products. It is to be noted that the sequence of operations remains same with the variety of products and sizes.

Advantages

The major advantages of this type of layout are:

1. Helps in job enlargement
2. Upgrades the skills of the employees.
3. Greater flexibility is possible.
4. Layout capital investment is lower

Group lay out

This type of layout brings an element of flexibility into manufacturing system as regards to variation in batch sizes and sequence of operations. Group Technology (GT) is the analysis and comparisons of items to group them into families with similar features. GT can be used to develop a hybrid between pure process layout and pure product layout. This technique is

very useful for companies that produce variety of parts in small batches to enable them to take advantage and economics of flow line layout.

The application of group technology involves two basic steps; first step is to determine component families or groups. The second step in applying group technology is to arrange the plants equipment used to process a particular family of components. This represents small plants within the plants. The group technology reduces production planning time for jobs. It reduces the set-up time. Thus group layout is a combination of the product layout and process layout. It combines the advantages of both layout systems.

Advantages of Group Technology Layout Group Technology layout can increase—

1. Component standardization and rationalization.
2. Reliability of estimates.
3. Effective machine operation and productivity.
4. Customer service.

It can decrease the—

1. Paper work and overall production time.
2. Work-in-progress and work

Fixed position layout

This is also called the project type of layout. In this type of layout, the material, or major components remain in a fixed location and tools, machinery, men and other materials are brought to this location. This type of layout is suitable when one or a few pieces of identical heavy products are to be manufactured and when the assembly consists of large number of heavy parts, the cost of transportation of these parts is very high.

Advantages

The major advantages of this type of layout are:

1. Helps in job enlargement and upgrades the skills of the operators.
2. The workers identify themselves with a product in which they take interest and pride in doing the job.
3. Greater flexibility with this type of layout.
4. Layout capital investment is lower.

UNIT-III

Plant Maintenance – organization for maintenance – Economics of Maintenance – VEIN analysis – Types of Maintenance – Merits and Demerits – Safety Engineering – Good House Keeping.

MAINTENANCE MANAGEMENT

"Maintenance is a routine and recurring activity of keeping a particular machine or facility at its normal operating condition so that it can deliver its expected performance or service without causing any loose of time on account of accidental damage or breakdown".

Once equipment is designed, fabricated and installed, the operational availability of the same is looked after by the maintenance requirement. The idea of maintenance is very old and was introduced along with inception of the machine. In the early days, a machine was used as long as it worked. When it stopped working, it was either repaired/serviced or discarded.

The high cost sophisticated machines need to be properly maintained/serviced during their entire life cycle for maximizing their availability. The development of mechanization and automation of production systems and associated equipment, with the accompanying development of ancillary services and safety requirements, has made it mandatory for engineers to think about proper maintenance of equipment.

Maintenance is a function to keep the equipment/machine condition by replacing or repairing some of the components of the machine. The maintenance concept is an outline plan of how the maintenance function will be performed. Based on the feedback obtained from the users and the history of the equipment, detailed procedures are drawn to concretize the maintenance concept. The procedures developed thus are collectively called the maintenance plan. The development of such a maintenance plan is one of the most important requirements of the maintenance program that requires interaction between the user and the manufacturer. With this information, the manufacturer will be in position to rearrange the design as per user's maintenance requirements.

Maintenance function also involves looking after the safety aspects of certain equipment where the failure of component may cause a major accident. For example, a poorly maintained pressure vessel such as steam boiler may cause a serious accident.

1.1 CHALLENGES IN MAINTENANCE:

The maintenance function of a modern industry faces a number of challenges attributable to:

- Rapid growth of technology resulting in current technology becoming obsolete. Such a challenge is a frequent one in Information and Communications Technology (ICT) industry where computers and computers based system (hardware and Software) is the main component.
- Advent of new advanced diagnostic tools, rapid repair systems, etc.
- Advance store management techniques to incorporate modular technologies.

Requirements of keeping both outdated and modern machines in service. For example, many industrial organizations have a combination of the old machines working on obsolete technology and new systems utilizing the latest technology and equipment. The effective management of maintenance aspects under such challenging circumstances is often a difficult job. Besides the rectification of the faults in the equipment, the activities of the maintenance department include:

- Up gradation of the existing plants and equipments and training maintenance personnel to attend the required technical skills.
- Effective maintenance of the old equipment for higher availability
- Cost optimization of all maintenance functions
- Improvement of maintenance activities in the areas of tribology and terrotechnology.
- Reconditioning of used /unserviceable spare parts.
- Development of indigenous sources for parts for import substitution.
- Setting up of an effective maintenance information management systems (MIMS).
- Effective utilization of the maintenance workforce
- Setting up of in house R&D activities for effecting improvements in maintenance practices.

OBJECTIVIES OF MAINTENANCE:

The objectives of maintenance should be formulated within the framework of the overall organizational setup so that finally the goals of the organization are accomplished. For this, the maintenance division needs to ensure that:

- The machinery and/or facilities are always in an optimum working condition at the lowest possible cost

- The time schedule of delivering to the customers is not affected because of non-availability of machinery/service in working condition
- The performance of the machinery /facility is dependable and reliable.
- The performance of the machinery /facility is kept to minimum to the event of the breakdown.
- The maintenance cost is properly monitored to control overhead costs.
- The life of equipment is prolonged while maintaining the acceptable level of performance to avoid unnecessary replacements.

Maintenance is also related with profitability through equipment output and its running cost. Maintenance work enhances the equipment performance level and its availability in optimum working condition but adds to its running cost.

The objective of maintenance work should be to strike a balance between the availability and the overall running costs. The responsibility of the maintenance function should, therefore, be ensure that production equipment /facilities are available for use for maximum time at minimum cost over a stipulated time period such that the minimum standard of performance and safety of personal and machines are not sacrificed. These days therefore, separate departments are formed in industrial organizations to look after the maintenance requirements of equipments and machines.

Organisation of physical facility

The following are the most important physical facilities to be organised:

1. Factory building
2. Lighting
3. Climatic conditions
4. Ventilation
5. Work-related welfare facilities.

I. FACTORY BUILDING

Factory building is a factor which is the most important consideration for every industrial enterprise. Factory building is required to provide protection for men, machines, materials. It should offer a comfortable working environment. It is for these reasons that the factory building acquires great importance.

Following factors are considered for an Industrial Building:

A. Design of the building.

B. Type of buildings.

A. Design of the Building

The building should be designed so as to provide a number of facilities— such as lunch rooms, cafeteria, locker rooms, crèches, libraries, first-aid and ambulance rooms, materials handling, facilities, heating, ventilation, air-conditioning, etc. Following factors are to be considered indesigning of a factory building:

1. Flexibility:

Flexibility is necessary because it is not always feasible to build a new plant, every time a new firm is organised or the layout is changed. With minor alternations, the building should be able to accommodate different types of operations.

2. Product and equipment

The type of product that is to be produced determines column-spacing, type of floor, ceiling, heating and air-conditioning. A product of a temporary nature may call for a less expensive building. Similarly, a heavy product demands a different building structure than a product which is light in weight.

3. Expansibility:

Growth and expansion are natural to any manufacturing units. The following factors should be taken in to account if the future expansion of the concern is to be provided for:

(i) The area of the land which is to be acquired should be large enough to provide for the future expansion needs of the firm.

(ii) The design of the building may be in a rectangular shape. Rectangular shapes facilitate expansion on any side.

(iii) If vertical expansion is expected, strong foundations must be provided.

4. **Employee facilities:**

The employee facility should be given enough consideration because it may affect the morale, satisfaction and attitude of the employees.

B. Types of Buildings

Industrial buildings may be grouped under two types:

1. Single-storey buildings,
2. Multi-storey buildings.

Choosing a suitable type of building for a particular firm depends on the manufacturing process and the area of land and the cost of construction.

1. SINGLE-STOREY BUILDINGS

If land is available, an organisation can construct single storey building. Single-storey buildings offer several operating advantages. A single-storey construction is preferable when materials handling is difficult because the product is big or heavy, natural lighting is desired and frequent changes in layout are anticipated.

Advantages

1. There is a greater flexibility in layout.
2. Expansion is easily ensured by the removal of walls.
3. low cost of transportation and material handling charges.
4. since all the equipment's are on the same level, effective layout supervision and control.
5. The danger of fire hazards is reduced because of the lateral spread of the building.

Limitations

Single-storey buildings have the following limitations. These are:

1. More land is required for building construction.
2. High cost of heating, ventilating and cleaning of windows.
3. High cost of transportation for moving men and materials to the factory

2. MULTI-STOREY BUILDINGS

Multi-storey buildings are useful in manufacture of light products, when the acquisition of land becomes difficult and expensive.

Advantages

1. Maximum operating floor space. This is best suited in areas where land is very costly.
2. Lower cost of heating and ventilation.
3. Reduced cost of materials handling because the advantage of the use of gravity for the flow of materials.

Limitations

Following are the disadvantages of multi-storey building:

1. Materials handling becomes very complicated. A lot of time is wasted in moving them between floors.
2. A lot of floor space is wasted on elevators, stairways and fire escapes.
3. Floor load-bearing capacity is limited.
4. Natural lighting is poor in the centres of the shop.
5. Layout changes cannot be effected easily and quickly.

Generally speaking, textile mills, food industries, detergent plants, chemical industries and software industry use these types of buildings.

II. LIGHTING

Good visibility of the equipment, the product and the data involved in the work process is an unavoidable factor in accelerating production, reducing the number of defective products and reducing waste. The use of natural light should be encouraged. Regular cleaning of lighting fixture is obviously essential. Excessive contrasts in lighting levels between the worker's task and the general surroundings should also be avoided. Artificial lighting will enable people to maintain proper vision.

III. CLIMATIC CONDITIONS

Control of the climatic conditions at the workplace is important to ensure the workers' health and comfort. With excess heat or cold, workers may feel very uncomfortable, and their efficiency drops. This can also lead to accidents. This human body functions in such a way as to keep the central nervous system and the internal organs at a constant temperature. It is essential to avoid excessive heat or cold, and wherever possible to keep the climatic conditions under control within the organisation.

IV. VENTILATION

Ventilation is an integral part of the good building system. Ventilation differs from air circulation. Ventilation replaces contaminated air by fresh air, whereas as the air-circulation merely moves the air without renewing it. Where the air temperature and humidity are high, merely to circulate the air is not only ineffective but also increases heat .Therefore, proper steps have to be taken to ensure the ventilation facility.

V. WORK-RELATED WELFARE FACILITIES

Work-related welfare facilities include basically drinking-water and toilets facilities. Others may seem less necessary, but usually have an importance to workers. The planners of the factory building have to see that the organisation has enough work related facilities for its employees. It is al made mandatory in the Factories Act.

1. DRINKING WATER

Safe, cool drinking water is essential for all types of work, especially in a hot environment. Without it fatigue increases rapidly and productivity falls. Adequate drinking water should be provided to employees.

2. SANITARY FACILITIES

Hygienic sanitary facilities should exist in all workplaces. They are particularly important where chemicals or other dangerous substances are used. Sufficient toilet facilities, with separate facilities for men and women workers, should be ensured.

3. FIRST-AID AND MEDICAL FACILITIES

Facilities for rendering first-aid and medical care at the workplace in case of accidents are essential. First-aid boxes should be clearly marked and conveniently located. They should contain only first-aid requisites absorption.

4.REST FACILITIES

Rest facilities help workers to recover from fatigue and to get away from a noisy, polluted or isolated workstation. A sufficient number of suitable chairs or benches should be provided. Rest-rooms enable workers to recover during meal and rest breaks.

5. FEEDING FACILITIES

Organisation should arrange food facilities for its employees. A snack bar, buffet or mobile trolleys can provide tea, coffee and soft drinks, as well as light refreshments. Canteens or a restaurant can allow workers to purchase a cheap, well-cooked and nutritious meal for a reasonable price.

6. RECREATIONAL FACILITIES

Recreational facilities offer workers the opportunity to spend their leisure time in activities likely to increase physical and mental well- being. They may also help to improve

social relations within the enterprise. Such facilities can include halls for sports, reading-rooms, libraries, clubs for hobbies and cinemas.

Objective of a good layout

1. To reduce material handling cost
2. To provide enough production facility
3. To utilise labour efficiency
4. To provide ease of supervision.
5. To improve productivity
6. To provide safety to employees
7. To reduce the number of accidents

TYPES OF MAINTENANCE SYSTEMS

Basically, maintenance can be divided into two groups:

i. Breakdown maintenance
ii. Planned maintenance

Breakdown Maintenance and Its Limitations

The basic concept of breakdown maintenance is not to do anything as long as everything is going on well. Hence, no maintenance or repair work is done until a component or equipment fails or it cannot perform its normal performance. In other words, the maintenance work is called upon when the machine is out of order, and repairs are required to bring back the equipment to its original working condition.

If the system is alone followed, it will lead to poor operational availability of the equipment, as spare parts may not be readily available. Though it appears to be economical proposition, work would greatly suffer if the machine is not restored to operational condition at the earliest. In this type of maintenance, during the repair time, no proper care is taken to know the real cause of the breakdown, which in turn may lead to frequent failures of the same kind.

This type of practice is economical for that machinery whose breakdown time and repair costs are less. But in case of high cost production systems, there are several limitations with breakdown maintenance.

Planned Maintenance:

The planned maintenance is said to be an organized type of maintenance. In this type of maintenance, the maintenance activities are planned well in advance to avoid random failure. It will be pre determined not only the when and what kind of the maintenance work, but also by whom it would be undertaken. The prerequisites for planned maintenance include the conduction of work study that decides the periodicity of maintenance work. Also the conduction of Time Study helps in suggesting ways and means of devising optimal maintenance schedules for the given system.

In planned maintenance, instructions will be in greater detail and specific for each type of equipment. Where safety is of paramount importance, the equipment condition should be checked everyday. Hence, the type of maintenance activity to be carried out will depend upon the nature of equipment and its working conditions.

The planned maintenance can be further classified into:

- Scheduled Maintenance (SM)
- Preventive Maintenance (PM)
- Corrective Maintenance (CM)
- Reliability Centered Maintenance (RCM)

1.Scheduled Maintenance:

This is a stitch-in-time procedure to avoid break-downs. The actual maintenance program is scheduled in consultation with the production department, so that the relevant equipment is made available for maintenance work. The frequency of such maintenance work is decided well in advance from experience so as to utilize the idle time of the equipment effectively. This also helps the maintenance department to use their manpower effectively. If the schedule of maintenance is known in advance, the specialists for the same can also be made available during the maintenance period. Though scheduled maintenance is costly compared to breakdown maintenance, the availability of equipment is enhanced. This practice is used for overhauling of machines etc.

2. Preventive Maintenance:

It is said to be preventive maintenance when planned and coordinated inspections, repairs, adjustments, and replacements are carried out to minimize the problems of breakdown maintenance. This is based on the premise that prevention is better than cure. This practice involves planning and scheduling the maintenance work without interruption in

production schedule and thus improves the availability of equipment. Under preventive maintenance, a systematic inspection of each item of equipment or at least the critical parts will be carried out at predetermined times to unfold the conditions that lead to production stoppage and harmful depreciation. There is no readymade preventive maintenance plan that suits for any industry. It should be customized to make it suitable to the requirements of the particular industry.

Planning and implementation of a preventive maintenance practice is a costly affair because it involves the replacement of all deteriorated parts/components during inspection. However, the higher cost of maintenance usually gets compensated by the prolonged operational life of the equipment. To avoid serious breakdowns, the preventive mode of maintenance is usually implemented in complex plants.

3.Corrective Maintenance

The practice of preventive maintenance brings out the nature of repetitive failures of a certain part of the equipment. When such repetitive type of failures are observed, corrective maintenance can be applied so that reoccurrence of such failures can be avoided. These types of failures can be reported to the manufacturer to suggest modifications to the equipment.

Corrective maintenance can be defined as the practice carried out to restore the full performance of the equipment that has stopped working to acceptable standards. For example, an IC engine may be in working condition, but does not make its full load because of worn– out piston rings. If the piston rings are replaced, it will bring back the performance of the engine to specified level.

4.Reliability Centered Maintenance (RCM):

It is used to identify the maintenance requirements of equipment. The RCM establishes the functional requirements and the desired performances standards of equipments and these are then related to design and inherent reliability parameters of the machine. For each function, the associated functional failure is defined, and the failure modes and the consequences of the functional failures are analyzed.

The consequences of each failure are established, which fall in one of the four categories: hidden, safety or environmental, operational, and no operational. Following the RCM logic, preemptive maintenance tasks which will prevent these consequences are selected, provided the applicability and effectiveness criteria for preventive maintenance are satisfied.

The applicability requirements refer to the technical characteristics and effectiveness criteria for preventive maintenance tasks and the frequency at which these should be carried

out. Effectiveness criteria depend on the consequences of the failure; probabilities of the multiple failures for hidden failure consequences, acceptable low risk of failure for safety consequences, and non-operational consequences. When the requirements for planned maintenance (PM) are not fulfilled, default tasks include failure finding (for hidden failure, possible redesign of equipment, procedures and training processes) and no-schedule maintenance.

MERITS OF MAINTENANCE:

The high involvement of capital cost in any production system expects proportional returns from the equipment. These expectations will be met only when the equipment keeps working at its normal performance. It is often experienced that the maintenance schedules provided by the manufacturer do not deliver the required results in terms of the production out put and the life of the equipment. In such cases, therefore, it becomes necessary to properly maintain the equipment with extra care in order to obtain the desired levels of production or service.

The following benefits can be derived from a well –organized maintenance system:

- The minimization of breakdown time
- Improvement in total availability of the system with their optimum capacity
- Extended useful life of the equipment
- Safety of the personnel.

The consequences of downtime can be very serious when the machine is working in a production line, as its failure will shut down the total system. Following a proper maintenance schedule the normal wear and tear of equipment can be reduced. In certain cases, the safety of the personnel is of prime importance and this also can be assured by proper planned preventive maintenance. For example, all aircraft systems need to be inspected before and after a flight as safety of the passengers is of prime importance.

DEMERITS OF MAINTENANCE:

Maintenance, being an important function in any production system, has far reaching effects on the system. If the right practice of maintenance is not established for a particular environment, it may lead to serious problem of either over maintenance or under

maintenance. The selection of a particular maintenance policy is also governed by the past history of the equipment. Cost effective maintenance will help in enhancing productivity. It is therefore, is important for the team associated with maintenance work, to know how much to maintain.

The nature of the maintenance function affects the life of equipment. It is known from experience that optimum maintenance will prolong the life of the equipment, and on the other hand, carelessness in maintenance would lead to reduced life of the equipment and in some cases an early failure as well. Further, proper maintenance will help to achieve the production targets. If the availability of the equipment in good working condition is high, the reliability of the production will also be high.

Another important effect of the maintenance function is the working environment. If the equipment is in good working condition, the operator feels comfortable to use it other wise there is a tendency to let the equipment deteriorate further. To get the desired results in maintenance operations, there should be selective development of skilled, semi skilled, and unskilled labour. And also proper job description is required for the jobs in order to make full use of skilled workforce available.

EQUIPMENT MAINTENANCE/ REPLACEMENT/ REENGINEERING:

To decide the effective mode of maintenance it is essential to carry out reliability analysis of critical parts of the equipment in all modern automated and semi-automated plants. These critical parts may be individual pieces of equipment or a combination of parts that from systems.

Before considering the purchase of any capital equipment, the evaluation of its reliability is essential, which directly depends upon the probability of failures. It is desirable to obtain a reliability index (numerical value) for each machine which is based on such factors as visual inspection tests and measurements, age, environment duty cycle of the equipment. These numbers, so calculated, represent the reliability of particular equipment. It is also possible to combine these indices and express an aggregate reliability index number for the complete system.

From the evaluation of the above index numbers, schedules can be set for equipment maintenance. Wherever needed, the maintenance efforts can be expanded. From the reliability reports it is possible to determine the actions that are required to maintain the operational availability at the desired level. Cost estimates for such maintenance for much maintenance functions can also be prepared based on the reliability information.

Similarly, the decision to replace existing equipment will require the consideration of the following questions, economic factors and reliability index numbers calculated for the existing equipment.

- Will the maintenance cost come down with the replacement of the old equipment?
- Will the cost per unit of production/service come down due to automated test features of the mew equipment?
- Is the existing equipment not sufficient to meet the future production/service targets?
- Will the new equipment be environment friendly and provide better safety to operators?
- Is there any possibility of adding additional accessories to existing equipment in order to make it more versatile for future use, or is the rebuilding of existing equipment possible through minor modifications?

Optimal replacement policy of the equipment can be determined if reliable estimates of revenue (return from equipment), up keep (maintenance cost) cost and replacement costs are available. The equipment in use in industries can be mainly divided into (1) equipment with diminishing efficiency and (2) equipment with constant efficiency. The first category deteriorates with time resulting in increase in operating cost including maintenance cost, and second category operates at constant efficiency for a certain time period and then deteriorates suddenly.

Several models have been developed using repair vs. time and cost, in order to solve the replacement problem of equipment with diminishing efficiency. Replacement is considered to be the regeneration point of whole life where the operating cost function initially starts. In practice such methods really work well and the life of the equipment/system is enhanced.

On the other hand the concept of reengineering in lieu of replacement is one viable model as the operating cost increases with time. This model maximizes the gain between the operating costs before and after the overhauls. Reengineering can be perceived as the adjustment, alteration, or partial replacement of a process or product in order to make it to meet a new need. Successful implementation of reengineering will improve the equipment or process performance and this reduces the maintenance and operating costs.

CONVENTIONAL REPLACEMENT PROBLEM:

The replacement problems are concerned with the issues that arises when the performance of an item decreases, failure or breakdown occurs. The decrease in performance or breakdown may be gradual or sometimes sudden. The need for replacement of items is felt when,

1. The existing item or system has become inefficient or require more maintenance.
2. The existing equipment has failed due to accident or otherwise and does not work at all.
3. The existing equipment is expected to fail shortly.
4. The existing equipment has become obsolete due to the availability of equipment with latest technology and better design.

The solution to replacement problem is nothing but arriving at the best policy that determines the time at which the replacement is most economical instead of continuing at an increased maintenance cost. The Main objective of replacement policy is to direct the organization in many situations so that it can take right decision. For Example, few situations are:

(i) Waiting for complete failure of item or to replace earlier at the expense of higher cost of the item.

(ii) Whether to replace the under performing equipment with the similar kind of item or by different kind (latest model) of item. The problem of replacement occurs in the case of both men and machines. Using probability it is possible to estimate the chance of death (failure) at various ages.

TYPES OF FAILURES

As the term ‘failure’ encompasses wider concept, failures can be discussed under the following two categories.

(a) **Gradual Failure**: In this, the failure mechanism is progressive. As the age of an item increases, its performance deteriorates. This results in:

- Increased operating cost
- Decreased productivity of the item
- Decrease in resale value of item

(Ex: Mechanical items like pistons, bearing rings, tyres, etc.,)

(b) **Sudden Failure**: This type of failure can be observed in the items that do not deteriorate gradually with age but which fail suddenly after some period of service. The time period between installation and failure will not be constant for any particular equipment. However the failure pattern will follow certain frequency distribution that may be progressive, retrogressive or random in nature.

1. *Progressive failure*: It is said to be progressive failure, when probability of failure increases with the age of an item. Ex: light bulbs, tyres etc.
2. *Retrogressive failure*: Certain items will have more probability of failure in the initial years of their life and with the increase in the life of an item the chances of failure become less. That is, the ability of the item to survive in the initial years of life increases its expected life. Aircraft engines exemplify industrial equipments with this type of distribution of life span.

   Random failure: It is said to be random failure, when constant probability of failure is associated with equipment that fails because random causes such as physical shocks that are independent of age. In the case of random failure, virtually all items fail before aging has any effect. For example, vacuum tubes, items made of glass or mirror, fruits, vegetables etc may fail independent of their age.

   The replacement situations generally are divided into the following four types:

- Replacement of capital equipment whose performance decreases with time, e.g., machine tools, vehicles in a transport organization, airplanes, etc.
- Group replacement items that fail completely, e.g., electrical bulbs, etc.
- Problem of mortality and staffing.
- Miscellaneous problems.

SAFETY ENGINEERING:

Safety engineering is an engineering discipline which assures that engineered systems provide acceptable levels of safety. It is strongly related to industrial engineering/systems engineering, and the subset system safety engineering.

Safety engineering is a field of engineering that deals with accident prevention, risk of human error reduction and safety provided by the engineered systems and designs. It is associated with industrial engineering and system engineering and applied to manufacturing, public works and product designs to make safety an integral part of operations.

The purpose of safety engineering is to control risk by reducing or completely eliminating it. It also aims to reduce the rate of failures and if failure does occur, it is not life threatening. Safety engineering usually begins during the design of a system or product development.

Safety engineers study possible accidents under various conditions and bring forward the accident risks. They then design safety guards or procedures the operators must follow to remain safe. Sometimes, they take the help of computer models, prototypes or replicate the situations to assess the hazards and risks. Before implementing a system or produce a product, safety engineers consider all possibilities, including, engineering, technical safety,

material reliability, legislations and human factors to make sure that there is no known hazard.

Safety engineering aims to insure that a life-critical system behaves as needed even when pieces fail.

In the real world the term "safety engineering" refers to any act of accident prevention by a person qualified in the field.

Safety engineering is often reactionary to adverse events, also described as "incidents," as reflected in accident statistics.

This arises largely because of the complexity and difficulty of collecting and analysing data on "near misses".

Increasingly, the importance of a safety review is being recognised as an important risk managament tool.

Failure to identify risks to safety, and the according inability to address or "control" these risks, can result in massive costs, both human and economic.

The multidisciplinary nature of safety engineering means that a very broad array of professionals are actively involved in accident prevention or safety engineering.

ROLE OF SAFETY ENGINEER:

- Health and safety engineers inspect facilities,
- machinery, and safety equipment to identify and correct potential hazards.
- Health and safety engineers must have a bachelor's degree,
- typically in an engineering discipline such as electrical,
- chemical, mechanical, industrial, or systems engineering.

GOOD HOUSE KEEPING:

Efficient production and a good working environment are complementary. The elimination of inefficiencies and accident hazards caused by unfavourable conditions in and about the workplace is essential in getting the job done properly and safely.

The attention to these important details—which may be overlooked when management’s attention is concentrated upon such amenities as good cloakrooms, canteens, rest rooms, recreational facilities, etc.—is widely referred to as “good housekeeping”.

Good housekeeping involves every phase of industrial operations and should apply throughout the entire premises, indoors and out. It is more than mere cleanliness. It requires

orderly conditions, the avoidance of congestion, and attention to such details as an orderly layout of the whole workplace, the marking of aisles, adequate storage arrangements, and suitable provision for cleaning and maintenance.

Good housekeeping is a vital factor in preventing accidents. The great majority of all work accidents are caused during the handling of goods or materials, and by people falling, being hit by falling objects, or striking against objects in the workplace. All these causes can be reduced by good housekeeping practices—in fact, good housekeeping is the only cure for hundreds of accidents that occur.

Here are some kinds of accidents commonly caused by ***bad*** **housekeeping:**

- Tripping over loose objects on floors, stairs and platforms.
- Articles dropping from above.
- Slipping on greasy, wet or dirty surfaces.
- Striking against projecting, poorly stacked, or mis-placed material.
- Tearing the hands or other parts of the body on projecting nails, wire, steel strapping on bales or crates, etc.

Typical examples of **poor housekeeping** that lead to these accidents are:

1. Excessive material, waste or chips in the working area.
2. Congested aisles.
3. Tools left on machines.
4. Waste containers overflowing.
5. Lockers and workrooms in disorder.
6. Acids in open containers.
7. Broken glass.
8. Electric leads or air lines across aisles.
9. Dirty light fittings, windows and skylights.

The following are the basic elements of a **good housekeeping** campaign that need attention:

- **Aisles—**Wide enough for traffic movements, marked off by floor lines from work positions and storage areas.
- **Space**—Sufficient room for the individual to work.
- **Storage**—Adequate and convenient space for materials and tools.

- **Materials Handling**—Layout planned for materials flow, with efficient methods and equipment.
- **Ventilation**—Good general ventilation plus local exhaust ventilation to remove air contaminants at the source.
- **Floors and Walls**—Of construction and materials that are easy to keep clean and in good repair.
- **Lighting**—Well-distributed artificial light and effective use of available daylight.
- **Amenities**—Clean, up-to-date washrooms and lockers for clothing. A clean, inviting lunch room for employees to eat their meals.
- **Waste Removal**—Adequate facilities to prevent congestion and disorder. Let us look at some of these elements in detail.

UNIT-IV

Production planning and control – objectives and Functions – Planning, Routing, Scheduling, Despatching, Expediting and Follow up – Charts.

PRODUCTION PLANNING AND CONTROL:

Production Planning is a managerial function which is mainly concerned with the following important issues:

- What production facilities are required?
- How these production facilities should be laid down in the space available for production? and
- How they should be used to produce the desired products at the desired rate of production?

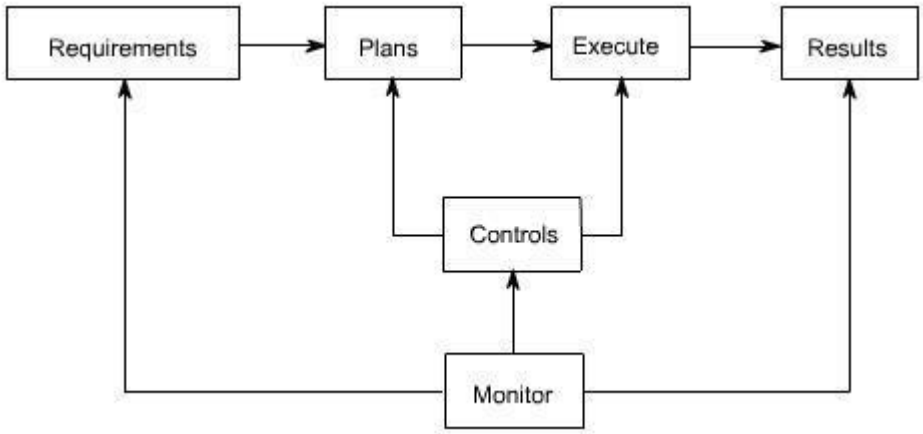
Broadly speaking, production planning is concerned with two main aspects: (i) routing or planning work tasks (ii) layout or spatial relationship between the resources. Production planning is dynamic in nature and always remains in fluid state as plans may have to be changed according to the changes in circumstances.

Production control is a mechanism to monitor the execution of the plans. It has several important functions:

- Making sure that production operations are started at planned places and planned times.
- Observing progress of the operations and recording it properly.
- Analyzing the recorded data with the plans and measuring the deviations.
- Taking immediate corrective actions to minimize the negative impact of deviations from the plans.
- Feeding back the recorded information to the planning section in order to improve future plans.

A block diagram depicting the architecture of a control system is shown in Figure1.

Figure 1: Architecture of Control System



Production Planning and control Functions

1. Materials Function:

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 & quantity) delivery dates, variety reduction (standardisation) 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 should follow to get transformed in to finished product.

The duties include:

(a) Fixation of path of travel giving due consideration to layout.

(b) Breaking don 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 standard times 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 Co-ordinate 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 authorises 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 centres 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 authorise 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 a logical step after dispatching which is called “follow-up” or “Progress”. It co-ordinates extensively to execute the production plan. Progressing function can be divided in to three parts, i.e. follow up of materials, follow up of work in process and follow up of assembly.

The duties include:

1. Identification of bottlenecks and delays and interruptions because of which the production schedule may be disrupted.

2. To devise action plans (remedies) for correct the errors.

3 To see that production rate is in line with schedule.

9. Inspection:

It is a measure 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 in 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 preplanning and planning will be effected by a feed back. The success of this step depends on the communication, Data and information gathering and analysis.

UNIT-V

Work Study – Method study and work measurement – Flow Process chart – Two handed process chart – Micromotion Study – Time Study Procedure and Techniques – Application of work study techniques

WORK STUDY

To survive in the current competitive and global environment, it is important for the organization to continuously look at ways to improve efficiency and productivity. It needs to discover a new, easy and cost-effective way of manufacturing or providing services.

Work study and industrial engineering play important role in job simplification, job design, job enrichment, value analysis/engineering, method analysis, operational analysis, etc. Work study has been utilized by companies to job productivity. Industrial engineering is the latest method employed to improve productivity. It deals with design, enhancement and setting up of engineering systems encompassing plants, machinery, workers, etc.

Work Study

Work study uses techniques like method study and work measurement to understand human work potential in terms of time spend on completing a task, looking at ways to make the task simpler and easy, as to increase productivity and efficiency. Work study is field used to finding ways of increasing on job performance, optimum usage of plant and machinery, standardization of work methods, etc. Therefore, objectives of work study are as follows:

- Scientific and controlled analysis of existing available methods of executing a task.
- Measuring performance of mentally and the physically qualified workers, establishing it as standard for performance measurement.
- Optimum utilization of workers, plant, machinery and other resources at minimum cost.
- Improved productivity and enhance worker mood.
- Increasing efficiency of organization.

For an organization, productivity can be increased over a period of time, if workers are efficient and are focused. Therefore, advantages of work study are as follows:

- Increase in production efficiency.
- Higher levels of production and optimum utilization of resources.
- Efficient flow of material and products.
- Efficient handling of material and better layout.
- Decreased cost of production as times spend on the job is decreased.
- Increased morale of workers with an increase in safety and efficiency.

- Benchmark and standard performance level are established, thus providing targets for organization.
- Better job satisfaction and incentive planning due to work study.

— A work-hour is the labour of one person for one hour.

— A machine-hour is the running of a machine or piece of plant for one hour.

The basic work content is the time taken to manufacture the product or to perform the operation if the design or specification of the product or service provided were perfect, if the process or method of operation were perfectly carried out, and if there were no loss of working time from any cause whatsoever during the period of the operation (other than legitimate rest pauses permitted to the operative). The basic work content is the irreducible minimum time theoretically required to produce one unit of output. This is obviously a perfect condition which never occurs in practice, although it may sometimes be approached, especially in line manufacturing or process industries.

Work study acts like a surgeon's knife, laying bare the activities of a company and their functioning, good or bad, for all to see. It can therefore "show up" people. For this reason it must be handled, like the surgeon's knife, with skill and care. Nobody likes being shown up, and unless the work study specialist displays great tact in handling people he or she may arouse the animosity of management and workers alike, which will make it impossible to do the job properly.

NATURE OF WORK STUDY:

- It is a means of raising the productivity of a plant or operating unit by the reorganization of work, a method which normally involves little or no capital expenditure on facilities and equipment.
- It is systematic. This ensures that no factor affecting the efficiency of an operation is overlooked, whether in analysing the original practices or in developing the new, and that all the facts about that operation are available.
- It is the most accurate means yet evolved of setting standards of performance, on which the effective planning and control of production depends.
- It can contribute to the improvement of safety and working conditions at work by exposing hazardous operations and developing safer methods of performing operations.

- The savings resulting from properly applied work study start at once and continue as long as the operation continues in the improved form.
- It is a "tool" which can be applied everywhere. It can be used with success wherever work is done or plant is operated, not only in manufacturing shops but also in offices, stores, laboratories and service industries such as wholesale and retail distribution and restaurants, and on farms.
- It is relatively cheap and easy to apply.
- It is one of the most penetrating tools of investigation available to management. This makes it an excellent weapon for starting an attack on inefficiency in any organization since, in investigating one set of problems, the weaknesses of all the other functions affecting them will gradually be laid bare.

METHOD STUDY AND WORK MEASUREMENT:

-Method study is the systematic recording and critical examination of ways of doing things in order to make improvements.

-Work measurement is the application of techniques designed to establish the time for a qualified worker to carry out a task at a defined rate of working.

Method study and work measurement are, therefore, closely linked. Method study is concerned with the reduction of the work content of a job or operation, while work measurement is mostly concerned with the investigation and of any ineffective time associated with it; and with the subsequent establishment of time standards for the operation when carried out in the improved fashion, as determined by method study.

Basic procedure of work study :

There are eight steps in performing a complete work study. They are:

(1) **Select** the job or process to be studied.

(2) **Record** or collect all relevant data about the job or process, using the most suitable data collection techniques (explained in Part Two), so that the data will be in the most convenient form to be analysed.

(3) **Examine** the recorded facts critically and challenge everything that is done, considering in turn: the purpose of the activity; the place where it is performed; the sequence in which it is done; the person who is doing it; the means by which it is done.

(4) **Develop** the most economic method, taking into account all the circumstances and drawing as appropriate on various production management techniques (explained in Part

Three), as well as on the contributions of managers, supervisors, workers and other specialists with whom new approaches should be explored and discussed.

(5**) Evaluate** the results attained by the improved method compared with the quantity of work involved and calculate a standard time for it.

(6) **Define** the new method and the related time and present it to all those concerned, either verbally or in writing, using demonstrations.

(7) **Install** the new method, training those involved, as an agreed practice with the allotted time of operation.

(8) **Maintain** the new standard practice by monitoring the results and comparing them with the original targets.

Method Study

It is a scientific process to better job design. It studies the existing job process and proposed job process as to identify the appropriate job process which results in efficient and cost effective operations. Therefore, objectives of method study are as follows:

- To study existing work process and proposed work process.
- To find out new methods of increased production and reduction of cost.
- To achieve optimum utilization of resources.

Method study ensures that there is an increase in overall productivity and profitability of organization. Method study involves following procedures:

- Selection of work to be studied.
- Recording the present method.
- Critical examination of the facts.
- Development of most practical, economic and effective method.
- Installation of new method.
- Maintenance of new method and practices checking

Industrial Engineering

Industrial engineering is concerned with developing the most effective and efficient way to use plant, machinery, materials, etc. The main objectives of industrial engineering are as follows:

- To increase productivity without incurring the incremental costs.
- To encourage automation as to decrease human intervention.
- To develop efficient and effective operation work cycle.

What is Time Management?

- Time Management refers to managing time effectively so that the right time is allocated to the right activity.
- Effective time management allows individuals to assign specific time slots to activities as per their importance.
- Time Management refers to making the best use of time as time is always limited.

  Ask yourself which activity is more important and how much time should be allocated to the same? Know which work should be done earlier and which can be done a little later.

  Time Management plays a very important role not only in organizations but also in our personal lives.

  Time Management includes:

i. Effective Planning
ii. Setting goals and objectives
iii. Setting deadlines
iv. Delegation of responsibilities
v. Prioritizing activities as per their importance
vi. Spending the right time on the right activity

- **Effective Planning**

  Plan your day well in advance. Prepare a To Do List or a "TASK PLAN". Jot down the important activities that need to be done in a single day against the time that should be allocated to each activity. High Priority work should come on top followed by those which do not need much of your importance at the moment. Complete pending tasks one by one. Do not begin fresh work unless you have finished your previous task. Tick the ones you have already completed. Ensure you finish the tasks within the stipulated time frame.
- **Setting Goals and Objectives**

  Working without goals and targets in an organization would be similar to a situation where the captain of the ship loses his way in the sea. Yes, you would be lost. Set targets for yourself and make sure they are realistic ones and achievable.
- **Setting Deadlines**

  Set deadlines for yourself and strive hard to complete tasks ahead of the deadlines. Do not wait for your superiors to ask you everytime. Learn to take ownership of work. One person who can best set the deadlines is you yourself. Ask yourself how much time needs to be

devoted to a particular task and for how many days. Use a planner to mark the important dates against the set deadlines.

- **Delegation of Responsibilities**

  Learn to say "NO" at workplace. Don't do everything on your own. There are other people as well. One should not accept something which he knows is difficult for him. The roles and responsibilities must be delegated as per interest and specialization of employees for them to finish tasks within deadlines. A person who does not have knowledge about something needs more time than someone who knows the work well.

- **Prioritizing Tasks**

  Prioritize the tasks as per their importance and urgency. Know the difference between important and urgent work. Identify which tasks should be done within a day, which all should be done within a month and so on. Tasks which are most important should be done earlier.

- **Spending the right time on right activity**

  Develop the habit of doing the right thing at the right time. Work done at the wrong time is not of much use. Don't waste a complete day on something which can be done in an hour or so. Also keep some time separate for your personal calls or checking updates on Facebook or Twitter. After all human being is not a machine.

  For Effective Time Management one needs to be:

  Organized - Avoid keeping stacks of file and heaps of paper at your workstation. Throw what all you don't need. Put important documents in folders. Keep the files in their respective drawers with labels on top of each file. It saves time which goes on unnecessary searching.

  Don't misuse time - Do not kill time by loitering or gossiping around. Concentrate on your work and finish assignments on time. Remember your organization is not paying you for playing games on computer or peeping into other's cubicles. First complete your work and then do whatever you feel like doing. Don't wait till the last moment.

FLOW PROCESS CHART:

Business Process Improvement programs have become the major tools for Organizations to keep working on their internal operations to enhance the operational efficiencies, to implement new processes in line with business requirement and to eliminate redundancies and wastage. When the Organizations used to be managed and run based on hierarchy and centralized decision making, the operations were dependent upon people. With the change in Organizational functioning and evolution of decentralized and process oriented organizational structure, the emphasis has shifted from people to process. With the help of

technology Organist ions today depend upon technology and process driven operations which is lends itself to flexibility and adaptability to changes in the business environment and Customer expectations.

With change of business operations and flexibility becoming the order of the day, Organizations have come to adapt Business Process Improvement program as the tool to manage the change. The selection of the particular process that is to be subject to Business Improvement program is done by the Business Unit Head or the Executive Implementation team that sponsors and owns the program.

It is the Business Heads and the senior management who would be in the right position to identify the particular process that would impact the business and is critical for the operation. The success of a BPI program however largely depends upon the training and skill sets of the Process Improvement Team and its leader. Business process improvement involves choosing a process, determining the boundaries, identifying and listing the input and output data requirements as well as drawing up a block diagram. Once this has been achieved, then comes the process of applying measurement criteria and targets to the process with an aim to be able to measure, assess, observe and control the process.

Working on measuring, detailing and enhancing the process calls for use of statistical tools and problem solving tools etc. The exposure to these tools as well as the experience of the PIT leader and team will determine how well the project will be executed and improvements take place.

One of the basic tools used in Business Improvement projects is the Flow Chart. It is a fact that any idea or message that is communicated through picture is absorbed faster and better than being presented in the form of text or data. We understand and grasp pictures better than words. Flowcharts are nothing but graphical presentation of the process using symbols, lines and other simple combination of words with figures. A flowchart presentation of a process enables the reader to understand the process clearly, to follow the exact sequence as it exists and comprehend all the transactions involved in the process as well as the interdependencies that exist with other processes.

Similar to a map, **a flow chart depicts the complete picture as it is and enables the reader or reviewer to navigate through, very easily**. Flow charting the process helps explain the entire process with clarity. However lengthy or complicated the process is, flow chart is able to present the same in detail and in whole. Being able to see the entire process including each and every activity as well as the interdependencies etc, enables the reviewer to identify roadblocks, problem areas as well as operational problems. Flow chart helps train the

process owners and staff in understanding the process with clarity and follow the same. Flow charts happen to be the best communication tools too.

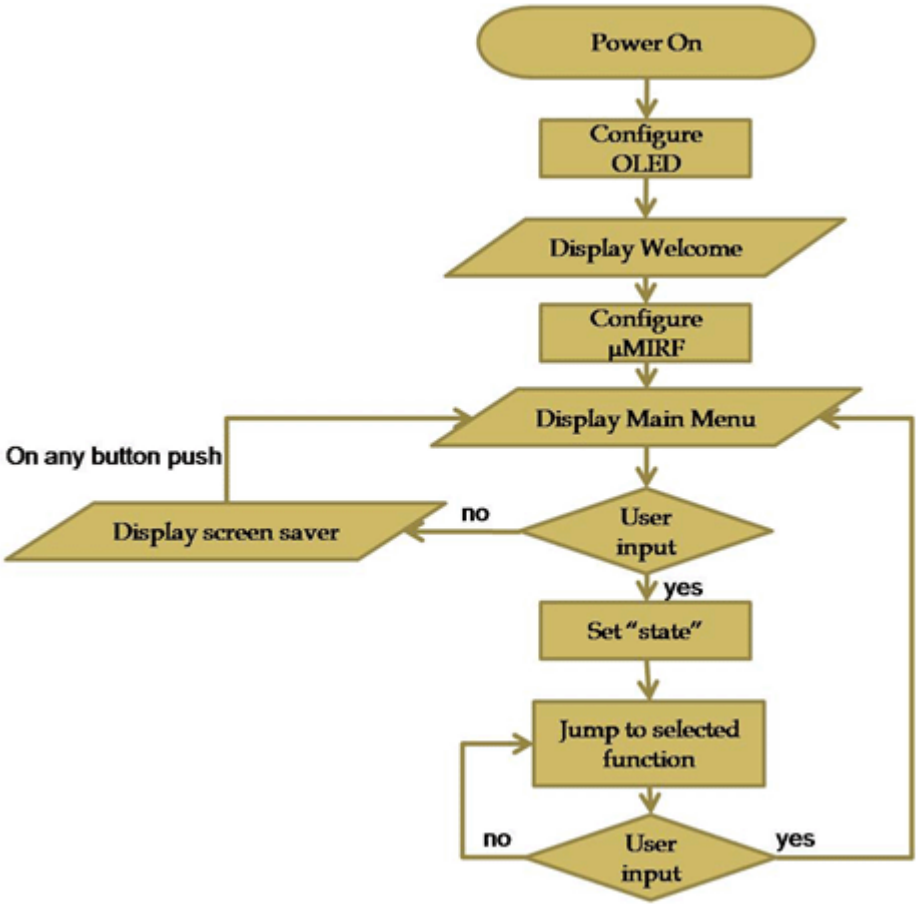
THREE KINDS OF FLOW CHARTS

- Block Diagrams
- ANSI Flow Charts
- Geographic Flow Charts.

Block Diagram

Block Diagrams are the simplest way of depicting the logical process flow or sequential tasks and activities. Block Diagrams use a series of rectangular blocks, lines and arrows to signify each task or activity, to indicate the direction of flow of activity and broken line to show the flow of communication etc. The starting and ending points of the process is depicted using rectangular rounded circle.

Block Diagrams are used to capture the process in sequence at the first instance. Each activity is described using verb and the flow chart provides an over view of the process to the viewer. However these charts do not capture the interdependencies or inputs and outputs of the process. An Organization Chart is the best example of a block diagram.



ANSI Flow Chart

If Block Diagrams capture the overall process, ANSI flow charts enable us to capture the process in detail including each and every task. More over each task or activity can be detailed out to the required level and the decision making as well as actions can be depicted. A ANSI flow chart enables the reader to follow through the detailed process and execute the tasks easily with clarity. Therefore ANSI flow charts are used for training purposes as well as for detailing improvements to the process.

ANSI (American National Standards Institute) flow charts use different types of symbols which have been developed as Standard Symbols.

Functional Flow Chart

Functional Flow charts are used to detail processes across various functional units across the organization or details the tasks that move across various task owners in sequence. Thus Functional Flow Charts can be used to explain the interdependencies between different stations or work units and provide an enhanced view of the process.

Functional flow charts are very useful in measuring movement of documents, data and decisions across various stations or task owners and are effective in monitoring as well as measuring the cycle time of the operations along with individual responsibility areas.

Geographic Flow Chart

Geographic Flow Chart goes one step further to include the timelines to each task as well as to depict the physical geographic locations involving each task. This additional dimension can throw up a better picture of the actual activity enabling the BPI team to look into the problems areas and hindrances to the process and work towards process improvement.

TWO HANDED PROCESS CHART

A chart in which the activities of a worker's hands (or limbs) are recorded in their relationship to one another. Generally used for repetitive operation, when one complete cycle of the operation is to be recorded.

BARNES' MOTION STUDY PRINCIPLES

• The two hands should begin as well as complete their motions at the same time.

• The two hands should not be idle at the same time except during rest periods.

• Motions of the arms should be made in opposite and symmetrical directions and should be made simultaneously.

• Materials and tools should be located to permit the best sequence of motions.

• Hand and lower arm movements are preferred to upper arm and shoulder movement for light work

• Rhythm is essential to smooth, automatic performance.

• Tool, materials and controls should be located close to and directly in front of the operator.

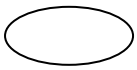
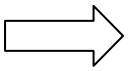
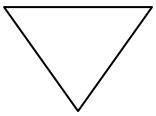
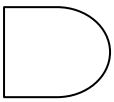
• Gravity feed bins and containers should be used to deliver materials close to the point of use.

• Drop deliveries should be used wherever possible.

• The hands should be relieved of all work that can be done by a jig, fixture or a foot operated device.

• Smooth continuous motions of the hands are preferable to straight-line or zigzig motion involving sudden and sharp change in direction.

Two Handed Process Chart Symbols:

OPERATION 	Used for the activities of grasp, position, use, release of tool, component or material.
TRANSPORT 	Used to represent the movement of the hand (or limb) to or from the work, a tool or material
HOLD(storage) 	Used to represent the activity of holding the work, a tool or material
DELAY 	Used to denote time during which the hand or limb being charted is idle

MICROMOTION STUDY

• It is a technique for recording and timing an activity.

• It consists of taking motion pictures of the operation with a clock in the picture (or with a video camera running at a known speed.

• The film is a permanent record of the method and the time and is always ready to be examined when needed.

Purposes of Micromotion Study

1. To assist in finding the preferred method of doing the work.

2. To assist in training the workers to understand the meaning of motion study and to enable them to apply motion economy principles in a professional way.

Micromotion study as an Aid in Improving Methods

The procedure of making a micromotion study consists of:

1. Filming the operation to be studied.

2. Analysing the film.

3. Charting the results of the analysis.

4. Developing the improved method. The speed of the camera used ranges from 960 to 1000 frames per minute. But faster cameras may be used to study very fast hand motions or complex operations. The pictures should be enlarged many times to facilitate the analysis of the motions.

Micromotion study should be used when it is economical to do so (short cycle highly repetitive operations, large volume production, or operation performed by a large number of workers).

Memomotion Study

In memomotion study, the camera speed is at 60 or 100 frames per minute. In addition to its use in industrial operations, it is used to study many other operations such as check-in operations as airline counters, the manner in which customers select items in the store, traffic flow on highways, and in banks. It costs less than micromotion study (only costs 6% of the cost of a micromotion study.

Fundamental Hand Motions

17 basic motions called therbligs (Gilbreth spelled backward).

1. **Search (Sh):** When the eyes or the hands are hunting (searching) for the object. It begins when the eyes or hands begin to search for the object and ends when the object is found.

2.**Select (St):** Choosing one object from several objects. Usually search and select are combined into one motion which is select. It begins when the eyes or the hands start to search and ends when the desired object is located.

3.**Grasp (G):** Taking hold of an object, closing the fingers around it before picking it up, holding it or manipulating it. It begins when the hand or fingers make contact with the object and ends when the hand has obtained control of it.

4.**Transport Empty (TE):** Moving the empty hand in reaching for the object. It begins when the hand begins to move without load or resistance and ends when the hand stops moving.

5.**Transport Loaded (TL):** Moving the object from one location to another. The object may be carried by hands or fingers or may be moved by sliding or pushing. It begins when the hand begins to move the object and ends when the hand stops moving.

6**.Hold (H):** Retention of an object after it has been grasped without any movement. It begins when the movement o the object stops and ends with the start of the next therblig.

7.Release Load (RL): Letting go of the object. It begins when the object starts to leave the hand and ends when the object is completely separated from the hand or fingers.

8.Position (P): Turning an object to prepare for fitting into location. Position may occur during transport loaded. Position begins when the hand starts to turn the object and ends when the object is properly oriented and placed in the desired position.

9.Pre-position (PP): The same as position except that the object is located in an approximate position making it ready for the next motion.

10.Inspect (I): Examining an object for a specific standard. It begins when the eyes or other parts of the body begin to examine the object and ends when the examination is completed.

11.Assemble (A): Placing one object into or on another object so that they become an integral part. It begins when the hand starts to move the part into its place in the assembly and ends when the hand has completed the assembly.

12. Disassemble (DA): Separating one object from another. It begins when the hand starts to separate or remove the object from the assembly and ends when the assembly has been separated.

13. Use (U): Manipulating a tool, device for the purpose for which it was intended. It begins when the hand starts to manipulate the tool and ends when the hand stops the application.

14. Unavoidable delay (UD): A delay beyond the control of the operator. It begins when the hand stops its activity and ends when the activity is resumed.

15. Avoidable delay (AD): A delay of the operator for which he is responsible for.

16. Plan (Pn): A mental reaction which precedes the physical movement. It begins at the point where the operator begins to think about the next step of the operation and ends when the procedure to be followed has been decided.

17. Rest for overcoming fatigue (R): A delay factor or allowance provided to permit the worker to recover from the fatigue incurred by work. It begins when the worker stops working and ends when the work is resumed.

TIME STUDY

It is the most versatile and the most widely used technique of work measurement.

Definition:

Time study is a technique to estimate the time to be allowed to a qualified and well-trained worker working at a normal pace to complete a specified task by using specified method.

This technique is based on measuring the work content of the task when performed by the prescribed method, with the allowance for fatigue and for personal and unavoidable delays.

Time Study Procedure:

The procedure for time study can best be described step-wise, which are self explanatory.

Step 1: Define objective of the study. This involves statement of the use of the result, the precision desired, and the required level of confidence in the estimated time standards.

Step 2: Verify that the standard method and conditions exist for the operation and the operator is properly trained. If need is felt for method study or further training of operator, the same may be completed before starting the time study.

Step 3: Select operator to be studied if there are more than one operator doing the same task.

Step 4: Record information about the standard method, operation, operator, product, equipment, and conditions on the Time Study observation sheet.

Step 5: Divide the operation into reasonably small elements, and record them on the Time Study observation sheet.

Step 6: Time the operator for each of the elements. Record the data for a few number of cycles on the Time Study observation sheet. Use the data to estimate the total number of observations to be taken.

Step 7: Collect and record the data of required number of cycles by timing and rating the operator.

Step 8: Calculate the representative watch time for each element of operation. Multiply it by the rating factor to get normal time.

Normal time = Observed time x Rating factor

Calculate the normal time for the whole operation by adding the normal time of its various elements.

Step 9: Determine allowances for fatigue and various delays.

Step 10: Determine standard time of operation.

Standard time = Normal time + allowances

Selection of job for Time Study

Time Study is conducted on a job

- which has not been previously time-studied.
- for which method change has taken place recently.
- for which worker(s) might have complained as having tight time standards.

Selection of Worker for Time Study

The selection of worker for time study is a very important factor in the success of the study. If there is only one person on the job, as usually is, then there is no choice. But if more than one person is performing the same operation, the time study man may time one or more of the workers. If all the workers are using the same method for doing the job and there is different in the rate of their doing it, it is necessary to select a suitable worker for the study. The worker on which time study should be conducted must

- have necessary skill for the job.
- have sufficient experience with the given method on the job (that is, he should have crossed the learning stage).
- be an ‘average' worker as regards the speed of working.
- be temperamentally suited to the study (those who can't work in normal fashion when watched, are not suitable for the study).
- have knowledge about the purpose of study.

Time Study Equipment

The following equipment is needed for time study work.

- Timing device
- Time study observation sheet
- Time study observation board
- Other equipment

Timing Device:

The stop watch is the most widely used timing device used for time study, although electronic timer is also sometimes used. The two perform the same function with the difference that electronic timer can measure time to the second or third decimal of a second and can keep a large volume of time data in memory.

Time Study Observation Sheet:

It is a printed form with spaces provided for noting down the necessary information about the operation being studied, like name of operation, drawing number, and name of the worker, name of time study person, and the date and place of study. Spaces are provided in the form for writing detailed description of the process (element-wise), recorded time or stop-watch readings for each element of the process, performance rating(s) of operator, and computation.

Time Study Board:

It is a light -weight board used for holding the observation sheet and stopwatch in position. It is of size slightly larger than that of observation sheet used. Generally, the watch is mounted at the center of the top edge near the upper right-hand corner of the board. The board has a clamp to hold the observation sheet. During the time study, the board is held against the body and the upper left arm by the time study person in such a way that the watch could be operated by the thumb/index finger of the left hand. Watch readings are recorded on the observation sheet by the right hand.

Other Equipment. This includes pencil, eraser, device like tachometer for checking the speed, etc.

Dividing Work into Short Elements

Timing a complete task as one element is generally not satisfactory. For the purpose of time study the task is normally broken into short elements and each element is timed separately, for the following reasons:

(1) To separate unproductive part of task from the productive one.

(2) To improve accuracy in rating. The worker may not work at the same speed throughout the cycle. He may perform some elements faster and some slower. Breaking of task into short elements permits rating of each element separately which is more realistic than just rating once for the complete cycle.

(3) To identify elements causing high fatigue. Breaking of task into short elements permits giving appropriate rest allowances to different elements.

(4) To have detailed job specifications. This helps in detection of any variation in the method that may occur after the time standard is established.

(5) To prepare standard data for repeatedly occurring elements.

The following guidelines should be kept in mind while dividing a task into elements.

(1) The elements should be of as short duration as can be accurately timed. (This in turn, depends on the skill of the time study man, method of timing and recording, and many other factors. Generally, with the stop watch, elements of duration less than 0.03 to 0.05 minute are difficult to time accurately. The elements should not normally be longer than 0.40 min.).

(2) Manually performed elements should be separated from machine paced elements. (Time for machine paced elements can be determined by calculation). Machine elements are not rated against a normal. This rule also helps in recognition of delays.

(3) Constant elements should be separated from variable elements. (Constant elements are those elements which are independent of the size, weight, length, or shape of the workpiece. For example, the time to pick screw driver from its place and bring it to the head of a screw is constant, whereas the time to tighten or loosen the screw is a variable, depending upon the length and size of the screw).

(4) The beginnings and endings of elements should be easily distinguishable. These should preferably be associated with some kind of sound.

(5) Irregular elements, those not repeated in every cycle, should be separated from regular elements. For example, if the jig is cleaned off after every ten parts produced, "cleaning" is an irregular element, and its time should be spread over ten cycles.

(6) Unnecessary motions and activities should be separated from those considered essential.

(7) Foreign or accidental elements should be listed separately. Such elements are generally of non-repetitive type.

Number of cycles to be timed.

The following general principles govern the number of cycles to get the representative average cycle time.

(1) Greater the accuracy desired in the results, larger should be the number of cycles observed.

(2) The study should be continued through sufficient number of cycles so that occasional elements such as setting-up machine, cleaning of machine or sharpening of tool are observed for a good number of times.

(3) Where more than one operator is doing the same job, short study (say 10 to 15 cycles) should be conducted on each of the several operators than one long study on a single operator.

It is important that enough cycles are timed so that reliable average is obtained.

Following techniques are used to determine the number of cycles to be timed.

(i) Use of Tables:

On the consideration of the cost of obtaining the data and the desired accuracy in results, most companies have prepared their own tables for the use of time study people, which indicate the number of cycles to be timed as a function of the cycle time and the frequency of occurrence of the job in the company.

(ii)**Statistical methods:**

On the basis of the requirements of the particular situation involved, *accuracy* and *confidence level* are decided (An accuracy of a confidence level of 95% is considered reasonable in most cases). A preliminary study is conducted in which some (say *N)* cycles are timed. Standard deviation o of these *(N)* observations is calculated as

$$\sigma = \sqrt{\left[\frac{1}{N}(t-T)^2\right]} = \frac{1}{N}\sqrt{N(\sum t^2) - (\sum t^2)}$$

Where t = each watch reading

T = average of N watch reading

n = number of watch readings in the preliminary study.

Now, to find M.the number of cycles to time. the following statistical method can be used.

calculated standard error of mean ε from the equation

$$X.\varepsilon = A.T$$

Where A = accuracy desired

t = average of N watch reading

X = a factor corresponding to confidence level desired. Its values is 1 for 68%, 2 for 95%, and 3 for 99% confidence level.

Determine the required sample size M from the equation

$$\varepsilon = \frac{\sigma}{\sqrt{M}}$$

(iii) Mundel Method: In this method the following steps are followed.

Step 1. Take a few good watch readings of the work cycle. (Generally, 10 readings are taken if cycle time is less than 2 minutes, otherwise 5 readings).

Step 2. Find the ratio $\frac{H-L}{H+L}$, where H and L are respectively the highest and the lowest value of the leading.

Step 3. Corresponding to the value of the ratio, determine the number of observations from the table.

APPLICATIONS OF WORK STUDY TECHNIQUES:

- Scientific and controlled analysis of existing available methods of executing a task.

- Measuring performance of mentally and the physically qualified workers, establishing it as standard for performance measurement.
- Optimum utilization of workers, plant, machinery and other resources at minimum cost.
- Improved productivity and enhance worker mood.
- Increasing efficiency of organization.

For an organization, productivity can be increased over a period of time, if workers are efficient and are focused.

Therefore, **advantages** of work study are as follows:

- Increase in production efficiency.
- Higher levels of production and optimum utilization of resources.
- Efficient flow of material and products.
- Efficient handling of material and better layout.
- Decreased cost of production as times spend on the job is decreased.
- Increased morale of workers with an increase in safety and efficiency.
- Benchmark and standard performance level are established, thus providing targets for organization.
- Better job satisfaction and incentive planning due to work study.
- Standard times for operations are useful for several applications in industry, like estimating material, machinery, and equipment requirements.
- Estimating production cost per unit as an input to
- Preparation of budgets
- Determination of selling price
- Make or buy decision
- Estimating manpower requirements.
- Estimating delivery schedules and planning the work
- Balancing the work of operators working in a group.
- Estimating performance of workers and using that as the basis for incentive payment to those direct and indirect labor who show greater productivity.

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