Uttar Pradesh Rajarshi Tandon Open University

Master of Business Administration

MBA-3.34

Production, Planning and Control

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BLOCK

1

INTRODUCTION

UNIT-1

Introduction

UNIT-2

Types of Production Systems

UNIT-3

Product Development and Design

UNIT-4

Profit Consideration

परिशिष्ट–4

आन्तरिक कवर–दो का प्ररूप

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लेखक Dr. Ekta Verma, Asst. Professor MONIRBA University of Allahabad, Prayagraj

सम्पादक Prof. J.N. Bhargawa, MONIRBA, University of Allahabad, Prayagraj.

परिमापक

सहयोगी टीम

संयोजक Dr. Gaurav Sankalp, SoMS, UPRTOU, Allahabd.

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UNIT-1 INTRODUCTION

Unit Structure

1.0 Unit Objectives

1.1 Meaning of Production Planning and Control

1.2 Objectives of Production Planning and Control

1.3 Scope of Production Planning and Control

1.4 Utility of Production Planning and control

1.5 Factors affecting PPC

1.6 Procedure of PPC

1.7 Elements of PPC

1.8 Requirements for an effective PPC

1.9 Functions of PPC

1.10 Parameters of PPC

1.11 Summary

1.12 Self Assessment Questions

1.13 References

1.0 UNIT OBJECTIVES

In this unit, objectives, scope, utility of production planning and control (PPC) are discussed. Factors, procedure, Elements and functions are also explained to have a better understanding of the PPC.

1.1 MEANING OF PRODUCTION PLANNING AND CONTROL

PPC is a very critical decision which is necessarily required to ensure an efficient and economical production. Planned production is an important feature of any manufacturing industry. Production Planning and control (PPC) is a tool to coordinate and integrate the entire manufacturing activities in a production system. This essentially comprises of planning production before actual production activities start and then exercising control over those activities to ensure that the planned production is realized in terms of quantity, quality, delivery schedule and cost of production.

According to Gordon and Carson, PPC usually involve the organization and planning of manufacturing process. Principally, it includes entire organization. The various activities involved in production planning are designing the product, determining the equipment and capacity requirement, designing the layout of physical facilities and material and material handling system, determining the sequence of operations and the nature of the operations to be performed along with time requirements and specifying certain production and quantity and quality levels.

Production planning also includes the plans of routing, scheduling, dispatching inspection, and coordination, control of materials, methods machines, tools and operating times. Its ultimate objective is the to plan and control the supply and movement of materials and labour, machines utilization and related activities, in order to bring about the desired manufacturing results in terms of quality, quantity, time and place. This provides a physical system together with a set of operating guidelines for efficient conversion of raw materials, human skills and other inputs to finished product.

1.2 OBJECTIVES OF PRODUCTION PLANNING CONTROL

The ultimate objective of Production Planning and Control, like that of all other manufacturing controls, is to contribute to the profits of the enterprise. As with inventory management and control, this is

accomplished by keeping the customers satisfied with meeting of the delivery schedules. Specific objectives of production planning and control are to establish routes and schedules for work that will ensure the optimum utilisation of materials, workers, and machines and to provide the means for ensuring the operation of the plant is in accordance with these plans.

1.3 SCOPE OF PRODUCTION PLANNING AND CONTROL

The function of production planning enables the manufacturing operation to boost efficiency and have clear insight within the operation. This visibility within the operation allows operation managers to make strategic decisions to aid production. Therefore, the scope of production planning and control include the following:

(a) **Nature of Inputs** : To manufacture a product, different types of inputs are used. The quality of the product depends upon the nature of the inputs are used. Hence the planning is done to determine the nature of various types of inputs which is a complicated process.

(b) **Quantity of Inputs** : To achieve a level of production, determination of quantity of the inputs and their composition is very important. A product can be prepared only when there is an estimate of the required composition of inputs.

(c) **Proper Co-ordination** : It ensures the proper coordination among the workforce, machines and equipment. This leads to avoidance of wastages and smooth flow of production.

(d) **Better Control** : Production planning is the method of control. For a better control, planning is a precondition. Only then, one can compare the performance and calculate the deviations which lead control of the production.

(e) **Ensure Uninterrupted Production** : The planning of materials ensures the regular supply of raw materials and other components. The regular flow of materials and supplies are helpful in the uninterrupted production.

(f) **Capacity Utilization** : There is a need to use the available resources effectively. It is helpful in bringing down various costs of production.

(g) **Timely Delivery** : If there is good production planning and control, there will be timely production and the finished product will be rushed to the market in time. This also ensures the better relationship with the customers.

1.4 UTILITY OF PPC PRODUCTIONS

The implementation of PPC based production system yields various advantages to any organization for various functional activities, which include the following:

a) **Last hour rush avoided :** Production is well planned and controlled as per the given time schedules. Therefore, production control reduces the number of emergency order and overtime works on plant and thus reduces the overheads.

b) **Problems areas of bottleneck get reduced :** The incomplete work or work-in-transit does not get piled up because production control balances the line and flow of work.

c) **Cost reduction :** An appropriate production control increases the men-machines utilization, which maintains in process inventories at a satisfactory level, leads to a better control on raw material inventories, reduces costs of storage and materials handling, helps in maintaining quality and limits rejections and thus ultimately reduces the unit cost of production.

d) **Optimum utilization of resources :** It reduces the time loss of the workers waiting for materials and makes most effectives use of equipment.

e) **Better coordination of plants activities :** PPC coordinates the activities of the plant that leads to control concerted effort by workforce.

f) **Benefits to workers :** PPC results into better efficiency and productivity, which leads to adequate wages stable employment, job security, improved working conditions increased job satisfaction and ultimately high morale.

g) **Improved services to customers :** PPC leads to better services to the customers as it ensures production in accordance with the time schedules and therefore, deliveries are made as per the committed schedules.

1.5 FACTORS AFFECTING PRODUCTION PLANNING AND CONTROL

Planning and Monitoring of output is very critical decision which is necessary to ensure a productive and economical production .PPC is an instrument for coordinating and integrating the entire manufacturing cycle into a production system. There are various factors that affect the Production Planning and Control. These are as follows:

a) **Use of Computers :** Modern factories are using office automation equipment like PC, punch cards etc. It helps in accurate computation of required of men and material.

b) **Seasonal Variations :** Demand of certain products is affected by seasons, for instance umbrellas and raincoats during the monsoons and outputs. Production Planning and Control must take such changes into consideration while planning and control activities of inputs and outputs.

c) **Test Marketing :** In an aggressive marketing strategy new products are to be test marketed in order to know the trends. This is a short- cycle operation, intermittent in nature and often upsets regular production.

d) **After Sales Service :** This has become an important parameter for success. In after sales services, many items are returned for repair. These are unscheduled Work and also overload the production line.

e) **Losses due to Unpredictable Factors :** Losses occur due to accidents, fire and theft of production inputs, mainly materials and Components. These are unpredictable. Shortage of input due to such factors upset the planned production schedule in time and quantity.

f) **Losses due to Predictable Factors :** There are losses of inputs, due to natural engineering phenomena like production losses and changes in consumption of materials and occurrence of defectives.

1.6 PROCEDURE OF PRODUCTION PLANNING AND CONTROL

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Figure : Production Planning Procedure

The PPC is entirely based on the pre-design format. It attempts to execute and implement all activities/operations according to the set plan. All operations should be executed in a proper manner with a close vigil on all facts ensuring that the time period and the stipulated costs should not go beyond the reach and it should be done under the excepted/agreed policies. These costs are including the cost of assets, capital cost of the facility, and labour. The PPC consists of the following steps.

a) Forecasting the demands of the customers for the products and services.

b) In advance preparing the production budget.

c) Design the facility layout.

d) Specify the types of machines and equipment.

e) Appropriate production requirements of the raw materials, labour, and machinery.

f) Drawing the apt schedule of the production.

g) Confirming the shortage or any excess of the end product.

h) Future plans are drawn for any sudden surge in the demand for the product.

i) The rate and scale of production is setup needs to be broken into realistic time periods and scheduling. The specified job needs to be done in the amount of time provided so that the production can move to next step.

PPC essentially consists of three Stages:

a) Planning stage

b) Action stage

c) Monitoring stage

All these three stages are very important from the point of view to production because without planning no production work can take off at all. The foremost thing which is required for any production is a proper planning.

1.7 ELEMENTS OF PRODUCTION PLANNING AND CONTROL

This is important to note that production plan is the first and the foremost element of PPC. Planning refers to deciding in advance what is to be done in future. A separate planning department is established in the organization which is responsible for the preparation of policies and plans with regard to production to be undertaken in due course. The planning department prepares various charts, manuals production budgets etc., on

the basis of information received from management. These plans and charts or production budgets are given practical shape by carrying various elements underproduction control. If production planning is defective, production control is bound to be adversely affected. For achieving the production targets, production planning provides sound basis for production control.

One needs to remember that production plans are prepared in advance at top level whereas, production control is exercised at machine shop floor (bottom level) where actual production is taking place. Some important elements of PPC have been depicted in the figure as below :

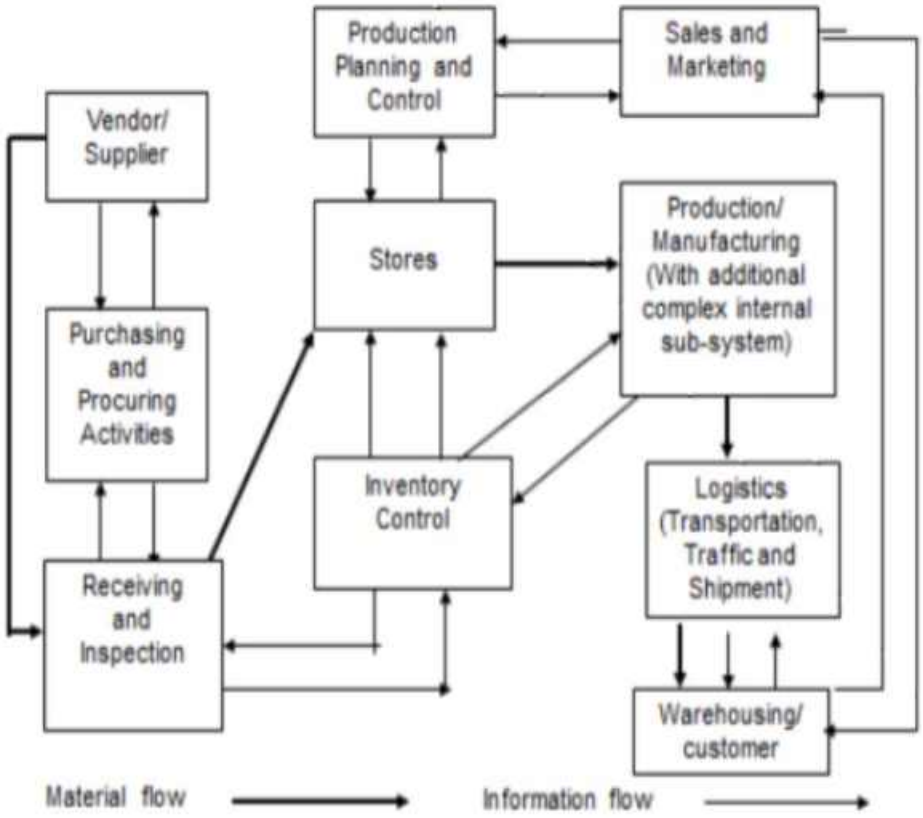


Figure : Elements of Production Planning and Control

The important elements may be listed as following:

1. **Materials :** Planning for procurement of raw material, component and spare parts in the right quantities and specifications at the right time from the right source at the right place. Purchasing, storage, inventory control, standardization, variety reduction, value analysis and inspection are the other activities associated with material.

2. **Method :** Choosing the best method of processing form several alternatives. It also includes determining the best sequence of operations (process plan) and planning for tooling, jigs and fixtures etc.

3. **Machines and equipment :** Manufacturing methods are related to production facilities available in production systems. It involves facilities planning, capacity planning, allocations, and utilization of plant and equipment, machines etc.

4. **Manpower :** Planning for manpower (labour and managerial levels) having appropriate skills and expertise.

5. **Routing :** Determining the flow of work, material handling in the plant, and sequence of operations or processing steps. This is related to consideration of appropriate shop layout plant layout, temporary storage location for raw materials, component and semi-finished goods, and of materials handling system.

   Route Sheet : A Route Sheet is a document providing information and instructions for converting the raw material in finished part or product. It defines each step of the production operations and lay down the precise path or route through which the product will flow during the conversion process. Route sheet contains following information:

   a) The operation required at their desired sequence

   b) Machines or equipment to be used for each operations

   c) Estimated set-up time and operation time per piece

   d) Tools, jigs, and fixtures required for operations

   e) Detailed drawings of the part, sub-assemblies and final assemblies

   f) Specification, dimensions, tolerances, surface finishes and quality standard to beachieved

   g) Specification of raw material to be used.

   h) Speed, feed etc. to be used in machines tools for operations to be carried on.

   i) Inspection procedure and metrology tools required for inspection

   j) Packing and handling instructions during movement of parts and sub assemblies through the operation stages.

6. **Estimating :** Establishing operation times leading to fixations of performance standards both for worker and machines. Estimating involves deciding the quantity of the product which needs to be produced and cost involved in it on the basis of sale forecast.

   Estimating manpower, machine capacity and material required meeting the planned production targets are like the key activities before budgeting for resources.

7. **Loading :** machine loading is the process of converting operation schedule into practices in conjunctions with routing. Machine loading is the process assigning specific jobs to machines, men, or work centres based on relative priorities and capacity utilization. Loading ensures maximum possible utilization of productive facilities and avoid bottleneck in production. It's important to either overloading or under loading the facilities, work centres or machines to ensure maximum utilization of resources.

8. **Scheduling :** Scheduling ensure that parts and sub-assemblies and finished goods are completed as per required delivery dates. It provides a timetable for manufacturing activities

   Purpose of scheduling :

   a) To prevent unbalance use of time among work and centres and department.

   b) To utilize labour in such a way that output is produced within established lead time or cycle time so as to deliver the products on time and complete production in minimum total cost.

9. **Dispatching :** This is concerned with the execution of the planning functions. It gives necessary authority to start a particular work which has already planned under routing and scheduling functions. Dispatching is release of orders and instructions for starting of production in accordance with routing sheet and scheduling charts.

10. **Inspection:** This function is related to maintenance of quality in production and evaluating the efficiency of the processes, methods and labours so that improvement can be made to achieve the quality standard set by product design.

11. **Evaluating:** The objective of evaluating is to improve performance. Performance of machines, processes and labour is evaluated to improve the same.

12. **Cost control:** Manufacturing cost is controlled by wastage reduction, value analysis, inventory control and efficient utilization of all resources.

1.8 REQUIREMENTS FOR AN EFFECTIVE PRODUCTION PLANNING AND CONTROL

In an organization, PPC system can be effective only if the following aspects are given due considerations before implementation:

a) Appropriate organization structure with sufficient delegation of authority and responsibility at various levels of manpower.

b) Right person should be deputed at right place for right job.

c) Maximum level of standardization of inventory, tooling, manpower, job, workmanship ,equipment, etc.

d) Appropriate management decision for production schedule, material control, inventory and manpower turnover and product mix.

e) Flexible production system to adjust any changes in demand, any problem inproduction or availability of material maintenance requirements, etc.

f) Estimation of accurate lead times for both manufacturing and purchase.

g) Management information system should be reliable, efficient and supporting.

h) Capacity to produce should be sufficient to meet the demand.

i) The facility should be responsive enough to produce new products change of products mix and be able to change the production rates.

The above elements are very important and necessary to make the production planning system effective and efficient.

1.9 FUNCTIONS OF PRODUCTION PLANNING AND CONTROL

Functions of production planning and controlling is classified into:

1. Pre-planning function
2. Planning function
3. Control function

The functions of production planning and controlling are depicted in the fig below:

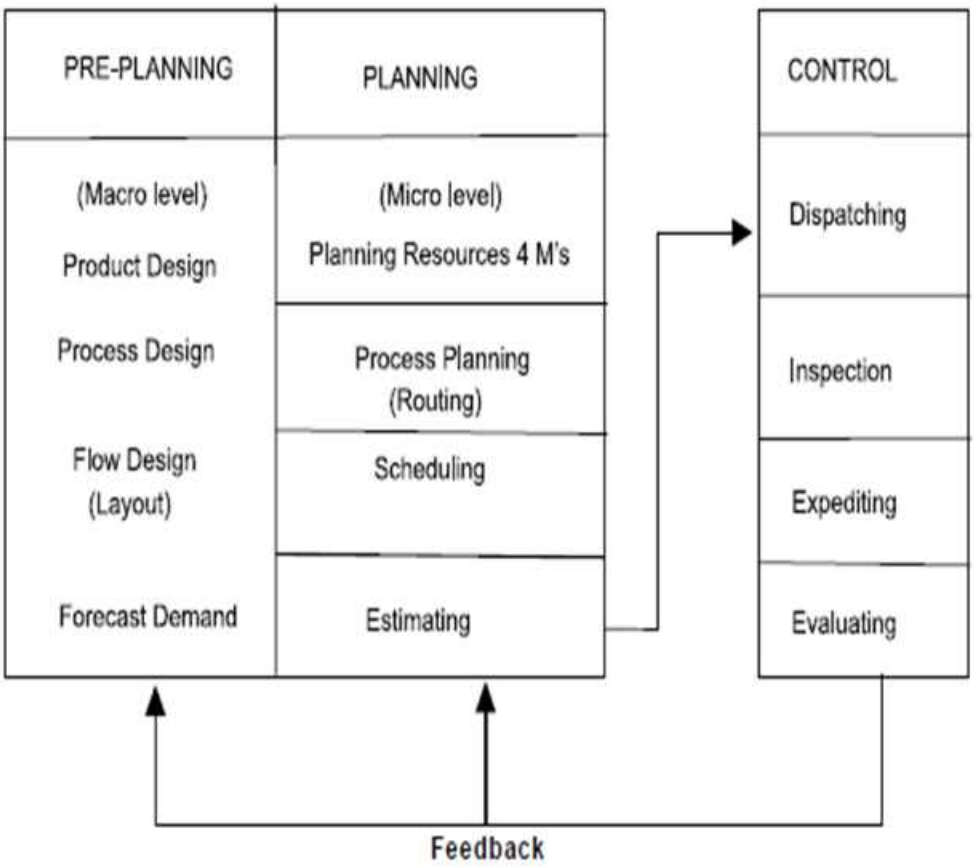


Figure : Functioning of Production planning and Control

1. PRE-PLANNING FUNCTION

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

PPC is concerned with decision-making with respect to methods, machines and work flow with respect to availability, scope and capacity.

2. PLANNING FUNCTION

The Planning function starts once the task to be accomplished is specified, with the analysis of **four M's**, *i.e.*, Machines, Methods, Materials and Manpower. This is followed by process planning (routing). Both short-term (near future) and long-term planning are considered.

Standardisation, simplification of products and processes are given due consideration.

3. **CONTROL FUNCTION**

Control phase is effected by dispatching, inspection and expediting materials control, analysis of work-in-process. Finally, evaluation makes the PPC cycle complete and corrective actions are taken through a feedback from analysis. A good communication, and feedback system is essential to enhance and ensure effectiveness of PPC.

1.10 PARAMETERS OF PPC

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

1. **Materials** : Raw materials, finished parts and bought out components should be made available in required quantities and at required time to ensure the correct start and end for each operation resulting in uninterrupted production. The function includes the specification of materials (quality and quantity) delivery dates, variety reduction (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. It is concerned with economy of jigs and fixtures, equipment availability. Thus, the duties include the analysis of facilities and making their availability with minimum down time because of breakdowns.

3. **Methods** : This function is concerned with the analysis of alternatives and selection of the best method with due consideration to constraints imposed. Developing specifications for processes is an important aspect of PPC and determination of sequence of operations.

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

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

   (*b*) Breaking down of operations to define each operation in detail.

   (*c*) Deciding the set up time and process time for each operation.

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

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

Thus the duties include:

(*a*) Loading, the machines as per their capability and capacity.

(*b*) Determining the start and completion times for each operation.

(*c*) To coordinate with sales department regarding delivery schedules.

7. **Dispatching :** This is the execution phase of planning. It is the process of setting production activities in motion through release of orders and instructions. It 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 logical step after dispatching which is called 'follow-up'. It coordinates extensively to execute the production plan. Progressing function can be divided into three parts, *i.e.*, follow up of materials, follow up of work-in-process and follow up of assembly. The duties include:

(*a*) Identification of bottlenecks and delays and interruptions because of which the production schedule may be disrupted.

(*b*) To devise action plans (remedies) for correcting the errors.

(*c*) To see that production rate is in line with schedule

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

limitations with respects to methods, processes, etc., which is very much useful for evaluation phase.

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

1.11 SUMMARY

- Production Planning and Control (PPC) is a tool to coordinate and integrate the entire manufacturing activities in a production system. PPC is a very critical decision which is necessarily required to ensure an efficient and economical production.
- Production Planning includes the plans of routing, scheduling, dispatching, inspection, coordination, control of materials, methods, machines, tools and operating times.
- The functions of production planning and controlling are - Pre-Planning function, Planning function and control function.
- Routing -It is concerned with selection of path or route which the raw materials should follow to get transformed into finished products.
- Scheduling- It is concerned with preparation of machine loads and fixation of starting and completion dates for each of the operations.

1.12 SELF ASSESSMENT QUESTIONS

1. Explain the concept of Production Planning and Control? Discuss its objectives and scope.
2. What are the elements of Production Planning and Control? Discuss the factors affecting PPC.
3. Discuss the utility of PPC. What are the requirements for an effective PPC?
4. What are the parameters that are considered in PPC? Discuss its various functions.
5. Explain in detail the procedure of PPC.
6. "PPC is a non-tangible function and it is very difficult to measure it's efficiency".Justify the statement.
7. Differentiate between production planning and production control.

8. What is scheduling? Discuss the purpose of Scheduling.

9. Discuss the role of production control system in enhancing the efficiency of production function.

10. What is Routing? List the information that should be included in the route sheet?

1.13 SUGGESTED BOOKS/REFERENCES

1. Cherry. S. N., Production and Operation Management, McGraw Hill Education.

2. Mahajan. M., Industrial Engineering and Production Management, Dhanpat Rai & Co.

3. Chunawalla. S.A., Production and Operations Management, Himalayan Publishing House.

UNIT-2 TYPES OF PRODUCTION SYSTEMS

Unit Structure

2.0 Unit Objectives

2.1 Production System

2.2 Elements of Production System

2.3 Types of Production System

2.4 Factors Affecting Selection of Production Process

2.5 Comparison of different Production System

2.6 Summary

2.7 Self-Assessment Questions

2.8 Suggested Books/References

2.0 UNIT OBJECTIVES

In this unit, the students will be able to comprehend the different types, its processes and importance of production systems.

2.1 PRODUCTION SYSTEM

A system is a logical arrangement of components designed to achieve particularobjectives according to a plan. According to Webster, "System is a regularlyinteracting inter-dependent group of items forming a unified whole". A systemmay have many components and variation in one component is likely to affectthe other components of the system e.g. change in rate of production will affectinventory, overtime hours etc. Production system is the framework within whichthe production activities of an organization are carried out. At one end ofsystem are inputs and at the other end output. Input and output are linked bycertain processes or operations or activities imparting value to the inputs.

These processes, operations or activities may be called production systems.The nature of production system may differ from company to company or fromplant to plant in the same firm.

Any manufacturing organisation is based on a production system. Production is a conversion process where inputs are received from the environment. These inputs are processed so as to produce goods desired by the society. The finished goods are outputs which are sold back to the

environment. The combination of activities and operations stated above employed to create goods is known as production system.

2.2 ELEMENTS OF PRODUCTION SYSTEM

(I) **Inputs :** Inputs are the physical and human resources utilized in the production process. They consist of raw materials, parts, capital equipment, human efforts etc.

(ii) **Conversion Process :** It refers to a series of operations which areperformed on materials and parts.

(iii) **Outputs :** Outputs are the products or completed parts resulting fromthe conversion process. Output generates revenue.

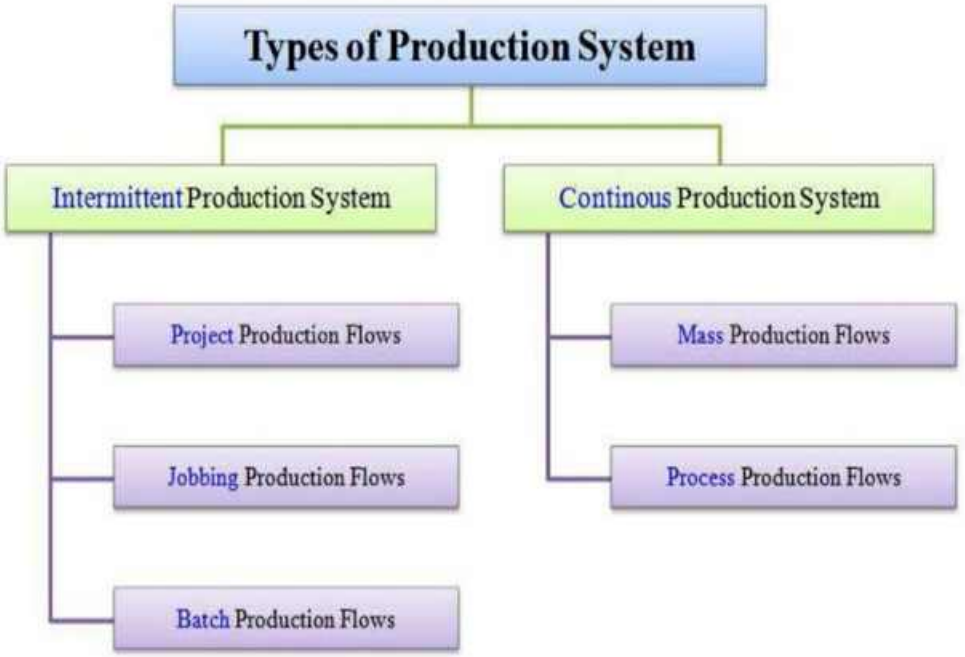
(Iv) **Storage :** Storage takes place after the receipt of inputs, between oneoperation and the other and after the output.

(v) **Transportation :** Inputs are transported from one operation to anotherin the production process.

(vi) **Information :** It provides system control through measurement,comparison, feedback, and corrective action.

2.3 TYPES OF PRODUCTION SYSTEMS

There are two main types of production systems: (i) Intermittent Production System (ii) Continuous Production System.



2.3.1 INTERMITTENT PRODUCTION SYSTEM

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

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

According to Buffa, "Intermittent situations are those where the facilitiesmust be flexible enough to handle a variety of products and sizes or where thebasic nature of the activity imposes change of important characteristics of the input (e.g. change in the product design). In instances such as these, no singlesequence pattern of operations is appropriate, so the relative location of theoperation must be a compromise that is best for all inputs considered together".In the industries following the intermittent production system, some componentsmay be made for inventory but they are combined differently for differentcustomers. The finished product is heterogeneous but within a range ofstandardized options assembled by the producers. Since production is partlyfor stock and partly for consumer demand, there are problems to be met inscheduling, forecasting, control and coordination.

(A) Characteristics :

(i) The flow of production is intermittent, not continuous.

(ii) The volume of production is generally small.

(iii) A wide variety of products are produced.

(iv) General purpose, machines and equipments are used so as to be adaptableto a wide variety of operations.

(v) No single sequence of operations is used and periodical adjustmentsare made to suit different jobs or batches.

(vi) Process layout is most suited.

Intermittent system is much more complex than continuous production becauseevery product has to be treated differently under the constraint of limitedresources. Intermittent system can be effective in situations which satisfy the following conditions:

(i) The production centres should be located in such a manner so that theycan handle a wide range of inputs.

(ii) Transportation facilities between production centres should be flexible enough to accommodate variety of routes for different inputs.

(iii) It should be provided with necessary storage facility.

(B) Advantages

- It enables to produce a large variety of products at low cost because of the use of general purpose machine.
- The capacity utilisation tends to be higher.
- Flexible to suit production variations.
- Each worker gets an opportunity to complete the job which gives him pride and sense of responsibility.

(C) Disadvantages

- It is relatively costly for larger volumes because of higher level of variable costs of general purpose machines.
- As the jobs are complex, the problems of planning and control tend to increase.
- In the process, inventory tends to be larger and stocks of work in progress also accumulate significantly.
- Many times costly equipment may be required
- for material handling, which also requires larger space.

2.3.2 TYPES OF INTERMITTENT PRODUCTION

(a) Project Production

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

(A) Characteristics of project production

The project production has certain characteristics as follows:

- **Short life cycle :** Projects have a short life cycle along with definite beginning and end.
- **Non uniform requirement of resources :** The resource requirement for project production is not uniform, because there are fewer requirements of resources in the beginning but the requirements of

resources builds up fast along with the progress of the project. More and more resources are absorbed, and then it levels off until there is steady cutback as the project move towards completion.

- **Fixed type of layout :** As the final product is huge in size there is immobility during the process of transformation.The operations are carried out in fixed position layout as in case of ship building or locomotives.
- **Involvement of many agencies :** A project generally involves different tasks, each having its own specialization to be performed by different agencies. The tasks generally are performed in a particular sequence (i.e. certain tasks must be completed before the next begins). Hence a proper coordination between different specialized is of utmost importance.
- **Scheduling and control :** as a large number of activities are to be performed by different special agencies in strict precedence, there is an urgency to have an effective scheduling and control. For this purpose, network planning techniques like Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM) has been observed to be more useful High cost of overruns: Many a times a project may be delayed because of certain unexpected events taking place, such delay turns out to be very costly because of increase in the cost of production and payment of heavy penalties.
- **Matrix form of organization :** When several projects have to be undertaken simultaneously matrix form of organisation is most suitable. The activities of the functional specialists are coordinated by the project managers.
- **Personnel problems:** Project production has many personnel related problems like:
- when there is a fast build up, staff is either borrowed from other departments or hired for short duration therefore, personnel involved in the project have limited (or short lived) interest in the project.
- Temporary manpower may start looking for alternative jobs when the project is in final state.
- As each project has limited duration some staff members may spend more time to get prepared for next project.
- Projects may be located in backward regions where socioeconomic infrastructure may not be well developed hence normal life may get dislocated.

(b) **Job Production :** Job or unit production involves the manufacturing of single complete unit with the use of a group of operators and process as per the customer's order. This is a 'special order' type of production. Each job or product is different from the other and no repetition isinvolved. The product is usually costly and non-standardised. Customers do not make demand for exactly the same product on a continuing basis and therefore production becomes intermittent. Each product is a class by itself and constitutes a separate job for production process. Ship building, electric power plant, dam construction etc. are common examples of job production.

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

(A) **Characteristics:**

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

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

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

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

- **Plant layout:** Plant and equipment is designed and arranged to obtain maximum flexibility. General purpose machines and handling equipments are capable of performing variety of operations with minimum time and cost. Similar machines, capable of doing similar

type of operations, are grouped together. The grouping of machines gives a lot of flexibility in scheduling and loading.

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

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

(B) Merits :

- It is flexible and can be adapted easily to changes in product design. A fault in one operation does not result into complete stoppage of the process. Besides it is cost effective and time-effective since the nature of the operations in a group are similar. There is reduced material handling since machines are close in a cell. The waiting period between operations is also reduced. This also results in a reduced work-in-progress inventory.

(C) Demerits :

- Job shop manufacturing is the most complex system of production e.g. in building a ship thousands of individual parts must be fabricated and assembled. A complex schedule of activities is required to ensure smooth flow of work without any bottlenecks. Raw materials and work-in-progress inventories are high due to uneven and irregular flow of work. Work loads are unbalanced, speed of work is slow and unit costs are high.

(b) Batch Production : It is defined as "The manufacture of a product in small or large batches or lots at intervals by a series of operations, each operation being carried out on the whole batch before any subsequent operation is performed". The batch production is a mixture of mass production and job production. Under it machines turn out different products at intervals, each

product being produced for comparatively short time using mass production methods.

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

(A) Characteristics of batch production

- The main features of Batch production may be stated as follows:
- **Knowledge of a specific process:** The supervisors possess considerable knowledge and are specialists in their own field. However, the need for supervisors in batch production tends to be lowered as compared to the job production.
- **Material handling:** As compared to the job production, material under batch production is small. Sometimes mechanisation of material handling systems may be used.
- **Huge work-in-progress:** Work in progress is comparatively large due to varying work content of different components, imbalances in production times, formation of queues linking the machines.
- **Plant layout and equipments:** General purpose machines and equipment are used in order to achieve flexibility. The machinery is arranged in process layout where machines carrying out similar jobs are placed together.
- **Need of production planning and control**: Functions of production planning and control in a batch production unit are more complicated as compared to job production.

(B) Demerits *:*

- Work-in-progress inventory is high and large storage space is required. Due to frequent changes in product design no standard sequence of operation can be used.

Machine set-ups and tooling arrangements have to be changed frequently.

- The main problem in batch production is the idle time between one operation and the other. The work has to wait until a particular operation is carried out on the whole batch

2.3.3 FLOW OR CONTINUOUS SYSTEM

Continuous production is characterised by complex activities that must be performed in a specific sequence within the given period and within the estimated cost. In fact, the production is stocked, hence it is necessary to carry out sales forecasting to estimate probable demand of the products and prepare schedule to adjust the sales forecast with the level of inventory. Inputs are standardised and standard process setup is adopted. As a result of routing and scheduling, the whole process can be standardised for smooth production process.According to Buffa, "Continuous flow production situations are those where the facilities are standardized as to routings and flow since inputs are standardized. Therefore a standard set of processes and sequences of process can be adopted". Thus continuous or flow production refers to the manufacturing of large quantities of a single or at most a very few varieties of products with a standard set of processes and sequences. The mass production is carried on continuously for stock in anticipation of demand.

(A) Characteristics :

(i) The volume of output is generally large (mass production) and goods are produced in anticipation of demand.

(ii) The product design and the operations sequence are standardized i.e. identical products are produced.

(iii) Special purpose automatic machines are used to perform standardized operations.

(iv) Machine capacities are balanced so that materials are fed at one end of the process and finished product is received at the other end.

(v) Fixed path materials handling equipment is used due to the predetermined sequence of operations.

(vi) Product layout designed according to a separate line for each product is considered.

(B) Merits:

(i) The main advantage of continuous system is that work-in-progress inventory is minimum.

(ii) The quality of output is kept uniform because each stage develops skill through repetition of work.

(iii) Any delay at any stage is automatically detected.

(iv) Handling of materials is reduced due to the set pattern of production line. Mostly the materials are handled through conveyer belts, roller conveyers, pipe lines, overhead cranes etc.

(v) Control over materials, cost and output is simplified.

(vi) The work can be done by semi-skilled workers because of their specialization.

(C) Demerits: Continuous system, however, is very rigid and if there is a fault in one operation the entire process is disturbed. Due to continuous flow, it becomes necessary to avoid piling up of work or any blockage on the line.

- Unless the fault is cleared immediately, it will force the preceding as well as the subsequent stages to be stopped. Moreover, it is essential to maintain standby equipment to meet any breakdowns resulting in production stoppages. Thus investments in machines are fairly high.

2.3.4 TYPES OF CONTINUOUS PRODUCTION

(a) Mass Production : Mass production refers to the manufacturing of standardized parts or components on a large scale. Mass production system offers economies of scale as the volume of output is large. Quality of products tends to be uniform and high due to standardization and mechanization. In a properly designed and equipped process, individual expertise plays a less prominent role. Thus Under mass or flow production items are produced in large quantities and consumer's orders are rarely entertained. Thus, production is mainly for stock and not as per order. Machines, methods, materials etc. are standardised and uniform and steady flow of materials is maintained through standardised sequence of operations to produce the output. This system can produce only one type of a product at one time.

(A) Characteristics

- Continuous flow of materials takes place and at any stage of processing there is no queuing.
- Special purpose machines are to be used and the plant assembly is based on product layout system.
- Highly skilled workers are not desired.
- Material handling tends to be less as materials move over short distances between different stages and is mostly done mechanically.

- Manufacturing cycle time is shorter.
- Supervision is easier on account of standardisation and hence very few instructions are required.

Breakdowns of machinery and equipments and absenteeism amongst workers affect the level of production and failure of one machine may give rise to complete stoppage of entire work system.

(b) **Process Production :** Production is carried on continuously through a uniform and standardized sequence of operations. Highly sophisticated and automatic machines are used. Process production is employed in bulk processing of certain materials. The typical processing Industries are fertilizers plants, petrochemical plants and milk dairies which have highly automated systems and sophisticated controls. They are not labour intensive and the worker is just an operator to monitor the system and take corrective steps if called for. Thus this system of production is similar to mass production system with more emphasis on automation in production process. The volume of production is very large. Generally a single product is produced on a very large scale and stocked awaiting sales. Flexibility tends to be absent because of production of single item only. Such processes of production are common in industries like sugar, cement, steel, paper and so on.

On the basis of the nature of production process, flow production may be classified into Analytical and Synthetic Production.

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

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

(A) Characteristics of process production

- The plant layout, shape and size of buildings, location of services are such that material flow is unidirectional at slow and steady rate, special purpose machinery and equipments with built in controls are used to regulate input and to measure output.
- Higher level of mechanisation in material handling is common.
- The manufacturing cycle time is near to zero because inflow of raw material at one end and the production of

finished goods at the other end is such that the whole plan is like one big machine.

- Work in progress tends to be very small on account of continuous flow of materials
- High quality supervision is required.
- Semi skilled workmen and skilled technicians are desired.

2.4 FACTORS AFFECTING SELECTION OF PRODUCTION PROCESS

There are several factors which affect the selection of production process such as :

- capacity of plant
- lead time
- flexibility
- environment
- demand

2.5 COMPARISON OF DIFFERENT PRODUCTION SYSTEMS

As we have discussed various systems and sub-systems in detail in the abovelines, we can now make a comparative study of them as follows:

(I) **Manufacturing Cost** : Cost of production per unit is lowest in processproduction while it is highest in job production because large scale continuousproduction is carried out under process production. Unit cost in mass production is higher than the process production while it is lower than the batch productionor job production.

(ii) **Size and Capital Investment :** As stated earlier, the scale of operationis small in job production, medium in batch production, large in mass productionand very large in process production. Hence the size of capital investment differs from system to system. Process production calls for the higherinvestment while mass production requires lesser amount of capital investment.It is lower in case of job production and comparatively higher in batchproduction.

(iii) **Flexibility in Production :** In case of change in demand of the product,the production facilities may be adjusted very shortly without increasing muchexpense under the system of job or batch

production. But both the sub-systemsof continuous production system i.e., mass production or process productionemploy single purpose machine in their manufacturing processes. They cannotadjust their production facilities so quickly and easily as is possible in job orbatch production where general purpose machines are used.

(iv) **Required Technical Ability :** Both job and batch production require highskilled technical foreman and other executives. But under mass production forprocess production systems, managerial ability plays an important role becauseit require higher ability for planning and coordinating several functions in massand process production than in the case of job and batch production.

(v) **Organisational Structure :** Mostly functional organization is adoptedin case of job and batch production systems. On the other hand, divisionalorganisation is preferred in mass and product process production systems dueto the greater emphasis for centralisation.

(vi) **Job Security :** Job and batch systems of production do not provide andtype of job security to workers due to their intermittent character. During odd times, workers particularly unskilled workers are thrown out of job. On thecontrary, mass and process production systems provide greater job security to workers because production operations are carried out continuously inanticipation of stable and continuous demand of the product.

(vii) **Industrial Application :** The application of different systems is suitablein differentindustries depending upon the nature of work. The mechanism of job production applies in products of construction and manufacturing industrieslike buildings, bridges, special purpose machines etc. Batch production is mostlyused in mechanical engineering and consumer-goods industries like cotton, jute, machine tools, shoe-making etc. Mass production is found in automobiles, sugar refining, refrigerators, electrical goods etc. Process production is mostappropriate in chemical, petroleum, milk processing industries etc.

Thus, a comparative view of the different systems of production reveals thatno one system is suitable for all types of industries and therefore each systemis different in itself and must be studied with reference to the nature of industry.

2.6 SUMMARY

- This chapter covered the production System and its two main types called intermittent and continuous process.
- Production is a conversion process where inputs are received from the environment. These inputs are processed so as to produce

goods desired by the society. The finished goods are outputs which are sold back to the environment. The combination of activities and operations stated above employed to create goods is known as production system.

- In intermittent method of production, the products are produced in large quantities to fulfil the orders made by the customers rather than producing from the stock. Intermittent production process is further classified into job production and batch production method.
- In continuous production the items are produced in large quantities and emphasis is not given to customer's orders. It is classified into mass or flow production and process production.
- This chapter also explains characteristics of each of the production process to make a right choice.

2.7 SELF ASSESSMENT QUESTIONS

1. Explain the concept of production system. Discuss it's elements.
2. What are the different types of production system? Where would each one of them be applicable? Give practical example.
3. Describe the primary inputs, outputs and conversion subsystems of electronic manufacturing.
4. What is job production? Explain its characteristics and merits and demerits.
5. Define batch production. Explain its merits and demerits.
6. Compare and contrast different types of production system.
7. What is intermittent production? Explain the types of intermittent production.
8. Explain the parameters that must be considered before finalizing the production system.

2.8 SUGGESTED BOOKS/ REFERENCES

1. Cherry. S. N., Production and Operations Management, Mc Graw Hill Education.
2. Mahajan. M., Industrial Engineering and Production Management, Dhanpat Rai & Co.
3. Chunawalla.S.A., Production and Operations and Management, Himalaya Publishing House.

UNIT-3 PRODUCT DEVELOPMENT AND DESIGN

Unit structure

3.0 Unit Objective

3.1 Definition of Product

3.2 Product Features

3.3 Components of Product

3.4 New Product Development

3.5 New Product development Process

3.6 New Product Adoption Process

3.7 Product life Cycle and its states

3.8 Product Design

3.9 Product Design Consideration

3.10 Product Design Tools

3.11 Design of Services

3.12 Flexible Manufacturing System

3.13 Process Design

3.14 Types of Processes

3.15 Summary

3.16 Self Assessment Questions

3.17 Suggested Books/References

3.0 UNIT OBJECTIVES

This chapter comprehensively explains product, its features, components and process of product development. It also deals with the product design, consideration for a good design and product design tools to provide clear understanding of product development and design.

3.1 DEFINITION OF PRODUCT

Product is one of the four elements of the marketing mix; the other three being price, place and promotion, which are all geared towards serving and satisfying the target market. Companies fix the product's price, promote and distribute it to the target market. Therefore, a product is the basic element of marketing mix. The word "Product" has several meanings, but it is generally a bundle of satisfaction that customers purchase or patronize in order to solve a problem. In our day-to-day life, we use many goods, such as soap, biro, book, ball, etc.; as well as services like banking transport, healthcare, or legal services. The term product has been defined differently by various authors and authorities in the field. For example, **Harry** defines a product as the sum of the physical and psychological satisfactions the buyer receives when he makes a purchase. It is thus a tangible and/or intangible attribute that is offered to the market for sales. Other definitions of a product include:

i. "A product is anything that can be offered to a market for attention, acquisition, use, or consumption that might satisfy a want or need: it includes physical objects, services, personalities, organizations, and ideas."**Philip Kotler**

ii. "Product is a bundle of utilities that satisfy the customer's needs and wants."**W. Alderson**

iii. "A product consists of the intrinsic features, extrinsic characteristics, and its intangibles associations." **H.L. Hansen**

Thus, from the above definitions, a product can be described as anything that is capable of providing solution to a customer's perceived problem whether it is physical or psychological.

Therefore, any product that fails to provide the needed solution to a customer is a not a good product. To this end, when a student buys a biro to write test but it fails to write smoothly, it is not a good product; or when you pay for a healthcare service but get poor service in return. So, to a consumer, the product is anything, which satisfies his needs and wants while to a marketer, the product is a bundle of attributes that can bring returns through satisfaction of customers. It is also pertinent to note that in marketing, the concept of a product covers goods, services, ideas, people, places, and organizations except otherwise specified.

3.2 PRODUCT FEATURES

To understand the concept of a product well, it is pertinent to consider the issue of product features. These features help to give a vivid description of a product and what a buyer is really buying in a given product. The important features of product are:

3.2.1. TANGIBLE FEATURES

A tangible product has some physical features that can be seen and handled, such as shape, size, colour, weight, etc. It can be touched and its physical presence can be felt. It is made up of materials like plastic, metals, iron, or wood. Products like perfumes, jewelleries, and wrist watches are sold in very attractive packages with esthetical appeals.

3.2.2. INTANGIBLE ATTRIBUTES

The core aspect of the product such as its performance, quality, dependability, and reliability are often built in the product or service and therefore intangible. These key attributes cannot be seen, but rather can be felt and experienced after using the product or patronizing the service. Some after-sales services, augmented services, and such pure services like tourism, story-telling, consultancy services, and counselling services fall in this category. Here, the organization is selling experiences or feelings.

1.1.3. Association features

Product may have associated attributes to facilitate its identification and acceptance by buyers.

Such attributes may be a brand name, package, warranty, credit terms, delivery terms, or payment options. For example, in Nigeria we have brands like Joy, Lux, Royal Foam, Egan, Tantalizers, etc., which depict positive brand associations.

1.1.4. Exchange value

For marketing purposes, every product, whether tangible or intangible, should have an exchange value and should be capable of being exchanged between buyer and seller, based on mutually agreed considerations. This exchange is a function of product value and the asking price. If the buyer feels that the value he is receiving from the product is equal or even higher than the money he is giving out, he feels satisfied and contented. Otherwise, he feels cheated and short changed and will most likely not buy it again and may even de-market the product if he gets the chance.

1.1.5. Customer satisfaction

The product should be able to satisfy consumer needs. Satisfaction can be both real and psychological. For example, when we eat food, wear clothes, or take medicines; we get a real satisfaction; whereas, when we buy insurance plan, services of travel agency, or beauty salon, we derive psychological satisfaction.

3.3 COMPONENTS OF A PRODUCT

In product development discourse, marketers should understand the key components that make up any product, be it a good or service. The

import of this is that it will enable companies to know what to incorporate in their product in order to produce a good and acceptable product. Products have three main components; the core, tangible, and augmented services.

1.2.1. Core Product

The core product constitutes the unique selling propositions of the product or service. It connotes the key benefits that a customer is looking for in a given product. Core product provides satisfaction to the customer, thereby becoming the main reason for producing and buying the product. It is an intangible attribute that is built in the product. For example, the core of a robot is performance through artificial intelligence; that of aspirin is pain relief, while the core of a school is imparting knowledge.

1.2.2. Tangible Product

This is a product component that can be seen, touched, and identified. In most cases, it is the tangible product that makes the core product tangible and ready for repeated purchases, especially packaging, brand names, marks, or symbol and distinctive colouring. For example, the colours of Chelsea and Manchester football clubs of England are blue and red, respectively.

1.2.3. Augmented Product

This is the support package that completes a total product offering such as after-sales service, warranty, delivery, and installation. At this level, the marketer prepares an augmented product that seeks to exceed customer expectations. For example, the hotel can include remote controlled TV, 24/7 free Wi-Fi internet service, fresh flower, room service, and prompt check-in and checkout.

3.4 NEW PRODUCT DEVELOPMENT

Product managers only manage the brands produced and introduced into the market. This goes to show that a company has to first develop a product or follow any legal means to acquire a product in order to sell it to the target market. For this reason, it may not be out of place if we appraise the ways through which a company obtains a product. A company can use any of the following ways to get a product, among others.

i) Merger with other company, such as the one between Nigerian Breweries and Consolidated Breweries, which increases the product portfolio of both companies.

ii) Acquisition of an existing company or brand, such as 7Up and Pepsi; Coca-cola and Limca as well as acquisition of Main street Bank limited from Asset Management Company of Nigeria (AMCON) by Skye Bank Plc.

iii) Licensing rights, such as Nigerian Bottling company makers of Coke under license from Coca-Cola Inc. of USA.

iv) iv.) Franchising arrangement, like that of McDonalds or Kentucky Fried Chicken (KFC) throughout the world.

v) Management contracting, as a system of marketing expert services such as coaching and technical advisory jobs. For example, the job of Zidane at Real Madrid or Mourinho of Manchester United.

vi) Leasing, a written or implied contract by which an owner (lessor) of an asset grants another party (lessee) the right to use and possess it exclusively for a specified period of time based on some conditions in return for a periodic rental payments.

vii) Hire purchase option for some specific assets.

viii) New product development option by which the company internally follows certain stages to come up with a new product.

3.5 NEW PRODUCT DEVELOPMENT PROCESS

New product development (NPD) is a complete process of creating and bringing a new product to market. New product development is the process of exploiting market opportunity by turning it into a product or service available for sale. A good understanding of customer needs and wants, the competitive environment and continuous practices, and strategies to better satisfy the customer requirements and increase their market share regulate development ofnew products. The notion of new product needs to be explained here. By and large, the newness of a product depends on what the customer or target market consider as new. For this reason, a new product can be an invention (entirely new which does not exist before), innovation (new to the company but existing in the industry), or product modification (changing the package, size, design and other features). There are eight steps involved in new product development namely:

i. Idea generation

ii. Idea screening

iii. Concept development and testing

iv. Business analysis

v. Marketing strategy development

vi. Product development

vii. Test marketing

viii. Commercialization

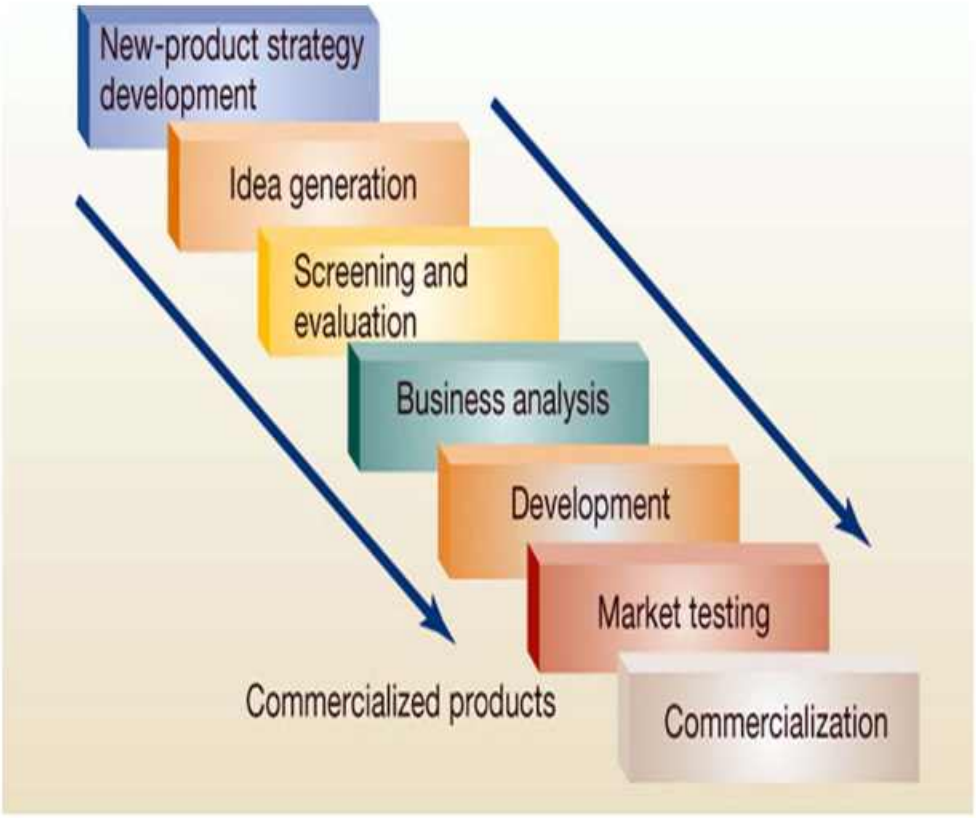


Figure : Steps of new product development

1. **Idea generation** : It is the act of getting as many ideas as possible. Ideas for new products can be obtained from customers, sales representatives, employees, distributors, company's research and development department, competitors, focus groups, or brainstorming. Lots of ideas are generated about the new product and out of these ideas some are implemented. Idea generation or brainstorming of new product, service, or store concepts usually begins when market opportunities are identified so as to support your idea screening phase.

2. **Idea screening** : It is the process of screening the ideas generated in order to do away with those ideas that are not consistent with the company's objectives and resources. This is with a view to eliminate ideas that are not feasible, viable, and acceptable. Many organizations use different criteria in screening the ideas, but in general, screeners often look at the viability, feasibility, and acceptability of the ideas at hand.

3. **Concept development and testing** : The ideas that pass through the screening stage are then developed into concept on paper stating clearly the marketing and engineering details of the product. In essence, the concept will indicate the target market for the product, its benefits, features, and attributes as well as the

planned proposed selling price for the product. Similarly, concept should contain the estimated cost of producing the product and its perceived competing brands in the chosen market. When the concept is developed, it has to be tested by asking a number of prospective customers to evaluate the idea based on its feasibility and marketability.

4. **Business analysis** : This stage of the new product development process is geared toward evaluating the overall cost, sales revenue, and profit potentials of the contemplated product idea. This is achieved through such analysis as industry's market potential, market size and growth rate, sales forecast and demand estimation, as well as the estimated profitability, and break-even point for the target product. The main purpose of this analysis is identifying those ideas that are apparently feasible and financially viable. Ideas that are not viable can also be dropped at this stage.

5. **Marketing strategy development** : The most viable ideas that scaled through the previous stages can be used as good candidates for marketing strategy development. In its basic form, this stage calls for formulating the product, pricing, distributing, and promotion strategies to be used in marketing the proposed products when it is introduced. It is pertinent to note that these strategies should be flexible such that it can be modified to conform to the dynamism of the environment.

6. **Product development** : It is at this stage that the actual or physical prototype of the successful idea will be produced. For example, if a company is producing an auto car it will produce a car prototype-like toy car containing all the features and designs specified in the concept development stage. If it is a service, a complete service package will be developed ready for test marketing.

7. **Test marketing** : Here, the company will test the product (and its packaging) in typical usage situations by conducting focus group customer interviews, dealer research or test it at trade shows to determine customer acceptance or otherwise. The company can use the outcome of the test to make adjustments on the planned marketing strategy where necessary. However, a company has to be extra careful in test marketing its planned new product in order not to expose it to competitors who can easily see and imitate it to come up with their own version sometimes even quicker and better than the initiator.

8. **Commercialization** : This is the final stage of the development process in which the new product will be launched or born. Once it is introduced, it is no longer under the company's control but that of the market. Here a company has to decide on when, where, and how to introduce the product. The timing of the launch is critical as it can make or mar the Product's success. For example, launching a new ice-cream during cold season is a wrong timing. The place or

venue of launching should also be strategic and closer to the target market. Similarly, a company has to decide on how it can launch the product. There are two main options here namely waterfall and sprinkler approaches. In waterfall approach, a company decides to commercialize it at once in the whole market, which is, introducing it to the whole Nigerian market at a go for instance. The other option is to launch it gradually from one section to another up to the time that the whole market is covered, thus using sprinkler technique. However, the choice of an option depends on the nature of the market, company's resources and level of competition in the market.

In addition, to make its commercialization successful, a company should produce and place an effective promotion to create awareness after ensuring that the products are adequately distributed throughout the market. This is because it will be counter productive for a company to promote a product that cannot be found in the market by potential buyers. Nevertheless, it is important to note that these steps may not be followed religiously as some stages may be eliminated or done concurrently in order to reduce the time that the new product development process takes. There are two types of new product development strategies namely proactive and reactive product development strategies. Most leading companies in the industry see new product development as a *proactive* process, where resources are allocated to identify market changes and seize upon new product opportunities before they occur. Conversely, a *reactive* strategy is adopted by follower and strong challengers in which nothing is done until problems occur or the pioneer company introduces an innovation. And because product development process typically requires both engineering and marketing expertise, cross-functional project teams are usually formed to execute the task. The team is responsible for all aspects of the project, from initial idea generation to final commercialization, and they usually report to senior management or project manager as the case may be. Thus, the path to develop successful new products points out three key processes that can play critical role in product development. They are talking to the customer, nurturing a project culture, and keeping it focused.

3.6 NEW PRODUCT ADOPTION PROCESS

The key to successful new product introduction is its acceptance by the customers and this is determined by the adoption process. Adoption process is a series of stages by which a consumer decides to adopt a new product or service. In today's competitive world, a consumer is faced with a lot of choices from a number of competing products. A consumer often passes through five stages in deciding to adopt or accept an innovation from awareness to adoption. These stages are briefly explained below.

1. **Awareness** : This is the step where major marketers spend a huge sum of money to create awareness about their innovation. This can

be done through intensive advertising campaigns, aggressive selling, use of consumer and dealer sales promotion, and e-marketing communication.

2. **Information search** : Following the dissemination of adequate information about the product, buyers in the market will be aware of the product and will look for more information in order to know it better. People search for information from company adverts, dealers, sales agents, and other consumers.

3. **Evaluation** : Here, the prospective buyer uses the information obtained to compare different product features and benefits such as price, performance, quality, availability, or durability. All this is an attempt to make rational decision.

4. **Trial** : It is usually done on products with low unit value and higher degree of divisibility.

   For technical products and other bigger assets, marketers use demonstration to enhance its trial ability. This is, however, difficult in services as services are generally intangible in nature. However, service marketing managers do find ways of offering trial packs to users, but it is easier in product marketing through sales promotional activities like giving out free samples, contests, premiums, discounts, etc.

5. **Adoption** : Based on the outcome of the trial process, this is where the consumer finally decides to adopt the product. It is expected that the customer will continue to buy the product repeatedly based on the satisfaction he/she derives from using the product or service. Otherwise, the process might end in rejection.

3.7 PRODUCT LIFE CYCLE AND ITS STAGES

Products are like human beings, they spend their life in the market. Some stay longer in the market, while others have a shorter life span. However, unlike human beings whose life is in the hands of God, the life of a product is controlled by the company and its market. It depends on whether it is adopted or rejected by the target market. Therefore, because companies know that the products they sell all have a limited lifespan, majority of them invest heavily on new product development in order to make sure that their businesses continue to grow. By and large, the product life cycle has four very clearly defined stages, each with its own characteristics. These stages are introduction, growth, maturity, and decline stage.

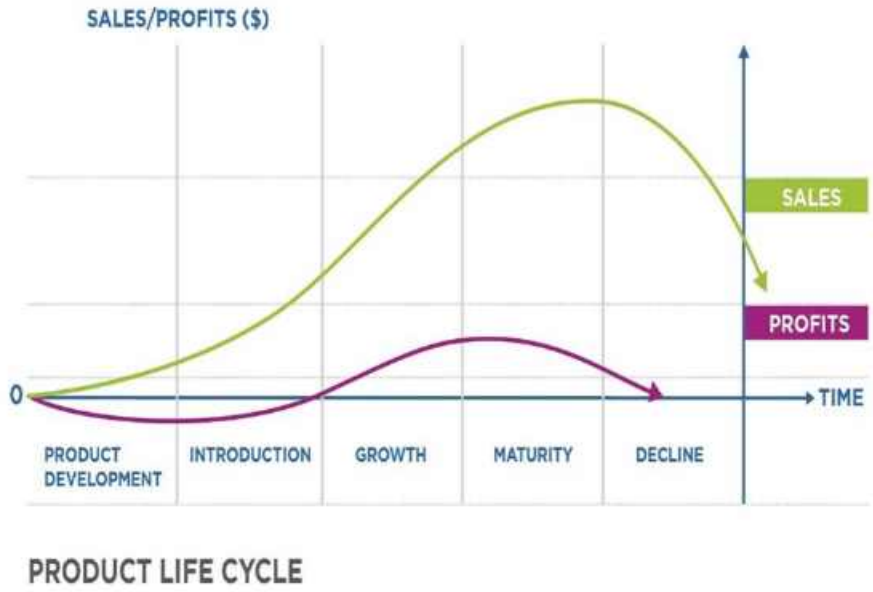


Figure : Product Life Cycle

Introduction Stage : Once a product is launched in the market, it enters into the introduction stage. This is the first stage in an ideal product life cycle. It is characterized by high promotion and intensive distribution especially for fast moving consumer goods (FMCG). These marketing activities often lead to increase in costs at the initial stage particularly for a company with a pioneering status which has to spend a lot to create awareness. It is at this stage that the product is formally born and it enters the competitive field in the market. This goes to show that once in a market, the product's life is determined by the market forces and the ability of the company to manage the product successfully in the market. Thus, if the product is accepted in the market, it will attract other competitors to the market if the market has no or low entry barriers. Otherwise, it may even die at this stage. This happened with Fanta blackcurrant soft drink brand of Nigerian Bottling company makers of Coca-cola which died immediately after introduction.

Growth stage : The growth stage is the next phase of the "S" shaped product life cycle. The growth here means increased sales of the product because it is widely accepted by the target market. As the sales rise, the market will also grow and revenues will now upset the initial cost of developing and launching the product resulting to profit generation. To maintain the growth momentum, a company has to emphasize brand preference in its promotion rather than brand awareness.

Maturity stage : When sales stabilize and market is saturated the maturity stage sets in. This is probably the most competitive time for most products and businesses. Companies here need to consider the strategy of product modifications, market expansion, or marketing mix modification, which might give them a competitive advantage. The aim here is to get more customers for the product. Organizations usually like to maintain their products in this stage in order to enjoy the cash inflows from the market, but it is very difficult to manage.

Decline stage : This stage is characterized by steady decrease in sales and profit in the market.

This may be because the product has lost its appeal with the customers or presence of better products in the market or the product becomes obsolete, and therefore needs further improvements. Companies do not like this stage because of its adverse consequences and will do everything possible to avoid it. However, for some products this stage is inevitable, and as a result, measures should be put in place to either resuscitate the product or phase it out of the market. In general, the main objective of the product life cycle stages is to enable product managers to know how they can enhance the performance of the products within the context of the company's business strategies.

3.8 PRODUCT DESIGN

A product design is a process of applying the various techniques and scientific principles for the purpose of defining a device, a process or a system in sufficient detail to permit its realization.

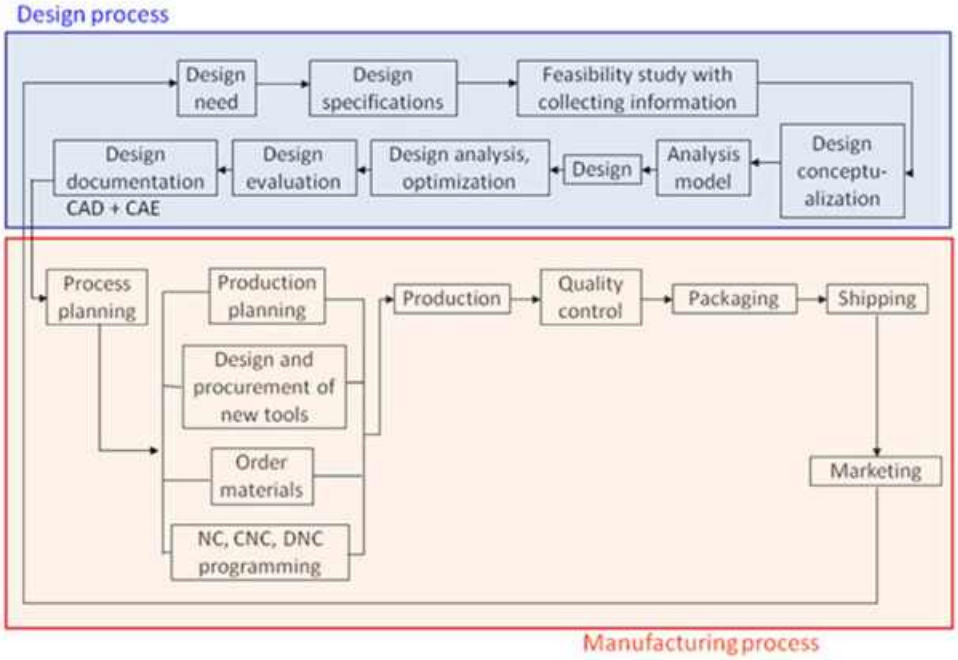


Figure : Product Design Process

3.9. PRODUCT DESIGN CONSIDERATION

Design is a multifaceted process. The various considerations in a good design can be grouped into three categories: (1) design requirements, (2) life-cycle issues, and (3) regulatory and social issues.

1. **Design Requirements**

It is obvious that to be satisfactory the design must demonstrate the required performance. Performance measures both function and behaviour of the design, i.e., how well the device does what it is designed to do.

i) Performance requirements can be divided into following two groups.

- **Functional Performance Requirements:** They address capacity measures such as forces, strength, energy, material flows, power, deflection, and efficiency of design, its accuracy, sensitivity etc.
- **Complementary Performance requirements:** They are concerned with the useful life of design, its robustness to factors in the service environment, its reliability, and ease, economy, and safety of maintenance. Issues such as built-in safety features, noise level in operation, all legal requirements, and design codes must be considered.

ii) *Physical Requirements*: These pertain to such issues as size, weight, shape, and surface finish.

iii) *Environmental Requirements*: There are two separate aspects. The first concerns the service conditions under which the product must operate. The extremes of temperature, humidity, corrosive conditions, dirt, vibration, noise, etc., must be predicted and allowed for in the design. The second aspect of environmental requirements pertains to how the product will behave with regard to maintaining a safe and clean environment, i.e., green design. Among these issues is the disposal of the product when it reaches its useful life.

iv) Aesthetic Requirements: They are concerned with how the product is perceived by a customer because of its shape, colour, surface texture, and also such factors as balance, unity, and interest.

v) Manufacturing Technology: This must be intimately connected with product design. There may be restrictions on the manufacturing processes that can be used, because of either selection of material or availability of equipment within the company.

vi) Cost : The final major design requirement is cost. Every design has requirements of an economic nature. These include such issues as product development cost, initial product cost, life cycle product cost, tooling cost, and return on investment.

1. Total Life Cycle

The total life cycle of a part starts with the conception of a need and ends with the retirement and disposal of the product.

i) Material Selection: Material selection is a key element in the total life cycle of a product. In selecting material for a given application, the first step is evaluation of the service conditions. Next, the properties of materials that relate most directly to the service requirements must be determined.

ii) Productibility: Material selection cannot be separated from Productibility. There is an intimate connection between design and material selection and the production processes. The objective in this area is a trade-off between the opposing factors of minimum cost and maximum durability.

iii) Durability: It is concerned with the number of cycles of possible operation, i.e., the useful life of the product.

Current societal issues of energy conservation, material conservation, and protection of environment result in new pressures in selection of materials and manufacturing processes. Energy costs, once nearly totally ignored in design, are now among the most prominent design considerations. Design of materials recycling is becoming more and more important consideration.

2. Regulatory and Social Issues

Specifications and standards have an important influence on design practice. The standards produced by such societies as ASTM, ASME, CE and BIS represent voluntary agreement among many elements (users and producers) of industry. As such, they often represent minimum or least common denominator standards. When good design requires more than that, it may be necessary to develop company or agency standards.

The code of ethics of all professional engineering societies requires the engineer to protect public health and safety. Increasingly, legislation has been passed to require government agencies to regulate many aspects of safety and health. The designer has to develop the design in such a way to prevent hazardous use of the product in an unintended but foreseeable manner. When unintended use cannot be prevented by functional design, then clear, complete, unambiguous warnings must be permanently attached to the product. In addition, the designer must be cognizant of all advertising materials, owner's manuals, and operating instructions that

relate to the product to ensure that the contents of the material are consistent with safe operating procedures and do not promise performance characteristics that are beyond the capability of the design.

An important design consideration is adequate attention to human factors engineering, which uses the sciences of biomechanics, ergonomics, and engineering psychology to assure that the design can be operated efficiently by humans. It applies physiological and anthropometric data to such design features as visual and auditory display of instruments and control systems. It is also concerned with human muscle power and response time.

3.10 PRODUCT DESIGN TOOLS

Several tools and techniques are available for efficient design and development of products.

These tools address all the stages of design and development. Some of the tools that are available for product designers to understand customers needs and translate them into meaningful design and manufacturing specifications, as well as some guidelines for incorporating the manufacturing requirements at the design stage.

3.10.1 UNDERSTANDING CUSTOMER NEEDS

The first step of product design and development process is to know what exactly the product is going to be. Organizations need various methods by which they can obtain information regarding the needs of the customers. This can be done by:

- **Market Research :** In market research, target group is identified and appropriate sampling is done within the target group. Using structured data collection methods, such as questionnaire surveys and interviews, information is solicited from the sample. The information is subjected to statistical and other analytical reasoning before arriving at customers' preferences and needs.

- **Competitive Analysis :** Understanding what the existing offerings are now and how the gaps and problems identified could be eliminated can sometimes offer valuable inputs to the designer. One method of competitor analysis is to "reverse engineer" the product. The competitors' product is dismantled down to individual components level and some detailed studies are conducted on them. These may sometimes reveal the probable processes utilized in their manufacture such as the choice of materials and their specifications and the relationship between these parameters and performance. *Reverse engineering,* is one crude method of a larger issue of benchmarking. In case of benchmarking, the competitive product offerings are chosen for detailed analysis. Specific parameters are chosen for the

benchmarking exercise. For example, cost, features, performance, ease in maintenance, ease of manufacture, assembly and distribution are some of the issues on which comparative study may be possible. Once these parameters are identified, data collection and analysis will reveal the positioning of ones' own products vis-à-vis the competitor's offerings. Another method for competitive analysis is to develop perceptual maps. *Perceptual maps* are graphical representation of various competitors offering and that of ones' own proposed product and/or service.

3.10.2 QUALITY FUNCTION DEPLOYMENT

The goal of good product design is to bring out products that satisfy customers needs better than those of the competitions. However, the attributes of competitor satisfaction are often qualitative in nature. On the other hand the product design process result in a bundle of quantitative attributes pertaining to the product. The challenge, therefore for a designer is to ensure that the transformation from qualitative attributes to quantitative ones is smooth and complete. Quality function deployment is a Japanese tool that helps organizations achieve this transition in a systematic and progressive manner Quality Function Deployment achieves these transition .in four stages. The first stage links customer needs to the design attributes required. In the second stage, the design attributes form the basis for actions that the firm needs to take to achieve these attributes. The actions identified at this stage are basis for third staging arriving at the specific decisions to be implemented. In the fourth stage the implementation decisions drive the process plan to be deployed.

3.10.3 VALUE ENGINEERING

Value Engineering refers to a set of activities under taken to investigate the design of components in a designing process strictly from cost-value perspective. Typically, the design professionals brain storm various options in conjunction with procurement, personnel, suppliers and production personnel, with respect to the value-cost dimensions of the product being designed. Usually several questions are addressed, which include the following:

(i) Can we eliminate certain features from design?

(ii) Are there instances of over design of certain components increasing the cost?

(iii) Are there certain features of design that cost more than they are worth?

(iv) Is it possible to replace the proposed method of manufacture with less costly ones?

(v) Is it possible to outsource some of the components?

(vi) Can we eliminate some parts and replace them with standard parts?

(vii) Are there opportunities for cost cutting by developing import substitution methods?

3.10.4 DESIGN FOR MANUFACTURABILITY

Design for Manufacturability (DFM) is a structural approach to ensure that manufacturing requirements and preferences are considered fairly early in the design process without the need of extensive coordination between the two. DFM guidelines address three sets of generic requirements:

Reducing the variety :

(i) Minimize the number of parts

(ii) Minimize subassemblies

(iii) Avoid separate fasteners

(iv) Use standard parts when possible

(v) Design parts for multi-use

(vi) Develop modular design

(vii) Use repeatable and understood processes

Reducing cost :

(i) Analyze failures

(ii) Assess value rigorously

Considering operational convenience :

(i) Simplify operations

(ii) Eliminate adjustments

(iii) Avoid too much complications

(iv) Design for minimum handling

(v) Design for top-down assembly

(vi) Design for efficient and adequate testing

3.10.5 TOOLS FOR MASS CUSTOMIZATION

Mass customization provides a structural set of ideas and tools to provide high levels of customization without increasing the complexity of planning and control operations. The various tools and techniques of mass customization are:

(i) Employ some variety reduction techniques

(ii) Promote modular design: The advantage of modular design is that with fewer subassemblies (or modules) it will be possible to create very large number of final products.

(iii) Make use of the concept of product platform: A product platform is a collection of assets that are shared by a set of products. These assets can be components, including parts, designs, mixtures and tools or manufacturing processes for manufacturing or assembly.

3.11 DESIGN OF SERVICES

Design of services involve the same stages as the design of products .It begins with identifying consumer needs and developing a service concept that fulfills the needs. When the Federal Express saw the need for fast, dependable shipping services, they developed a new delivery system that features private ownership, a limited range of services, and a complete pick-up-process delivery cycle that emphasizes convenience and nationwide accessibility detailed design of its services design. Identifying the concept led to and unique processing technologies (including equipment, human resources, and procedures), and continues today with refinement and redesign of services. Although the generic steps may be the same, there are some significant differences between product and service design. Services that do not include physical component do not require the engineering, testing, component analysis, and prototype building of the product design. Further along in service design, the process technology involves different issues and considerations than those for products, primarily because the client or consumers are present in the conversion process.

Process technologies for services are at least as diverse, and perhaps more so, than product process technologies. Services vary in the amount of customer contact and in the intensiveness of labor versus capital. Service process technologies vary accordingly.

3.12 FLEXIBLE MANUFACTURING SYSTEM

Batch manufacturing has always had inherent limitations on account of mid-volume, mid variety nature of manufacturing. Work- in-process levels are generally high and machine utilization tends to be low. Job spend a high proportion of time waiting for machine to be set up, waiting to be moved or waiting for other jobs on the machines to be completed. Batch production often requires an army of expeditors, progress chasers to keep jobs flowing through the manufacturing facilities. In batch type manufacturing, some studies conducted revealed that only 5 percent of the total time spent on the shops unnecessary waiting of jobs and so on. One way to improve productivity is to use technology to obtain a better process.

These requirements could be met with the aid of computers and numerical control techniques using the basic concepts of Flexible

Manufacturing Systems (FMS) Job shops are designed to produce a variety of products. They usually tend to have low production rate, high manufacturing lead time, more WIP, and more inventories of finished goods. On the other hand, flow shops are designed for mass production. Consequently, they are less flexible to change. The change over a period of time is very high, as it involves redesigning of template, cam switches, dies; fixtures etc. FMS is a combination of job shopped flow in the sense that a limited variety with reasonably quick change over time is possible.

An FMS is a manufacturing system that actually consists of numerical control (NC) machines connected by an automated material handling system. It is operated through central computer control and is capable of simultaneously processing a family of parts with low to medium demand, different process cycles and operation sequences. We can characterize the typical features of FMS as follows:

- It is an attempt to solve the production problem of mid-volume and mid variety parts for which neither high production rate transfer lines nor highly flexible stand-alone NC machines are suitable.
- It is designed to process simultaneously several types of parts in the given mix.
- It is equipped with sophisticated flexible machine tools that are capable of processing a sequence of different parts with negligible tool change over time.
- Parts are transferred from machine to machine by Computer controlled machine handling system. It consists of three subsystems (i) the machining system (ii) the material handling systems (iii) the control system
- FMS technology results in the reduction of direct and indirect labor force.

With the level of automation that is employed in the subsystem, it is possible for a worker to attend to a group of machines in the system. The following is the role of human labor in the FMS: loading and unloading, tool set up, tool replacement, work piece set up off-line Maintenance of the system, multi-task monitoring (3to8 machines) Supervision of the overall system taking decisions using the information supplied by the computer system.

The technologically advanced features of the FMS, in part, simplify process designs and complexities in flow in an intermittent flow system in batch manufacturing by offering the following flexibilities:

- Machine flexibility
- Process flexibility
- Routing flexibility

- Volume flexibility

3.13 PROCESS DESIGN

At the product conception stage, manufacturing proposes investigates processes and concepts.

When the product concept has been finalized, the role of process management then is to develop cost estimates, define process architecture, conduct process simulation and validate suppliers. Concurrently with the detailed product design, process management is involved in the designing of the process, designing and developing tooling and participating in building full-scale prototype. At the time the product development teams are developing the prototype, the process management teams test and try out tooling and equipment; help build second-phase; an assembly line is a prototypes; install equipment and specify process procedures.

This is followed by building pilot units in commercial process; refining process based on pilot experience, training personnel's and verifying supply channels. Finally at the release of product, process management has to ramp up plan to volume targets, meet targets for quality, yield and cost. The analytical work of process planning can be divided into two classes:

- Process analysis,
- Operation analysis

- **Process analysis :** It is governed by the main process decisions namely, capital/labor intensity, outsourcing, resource flexibility and volumes. These four decision areas represent broad strategic issues that have to decide prior to finalizing the process design. It is concerned with the overall set of operations constituting the process. Process analysis is not directly concerned with the content of operations constituting the process, or with the detailed method of carrying out the operations. It comes out with recommendations for primary (work station) and secondary equipment (accessories) required for the most effective and efficient production of the products and work flow. The process analysis decisions are reflected in a route sheet. A route sheet normally specifies the sequence of operations in a process by name and numbers. A rout sheet is prepared for each component.

- **Operation Analysis :** Once the process analysis decisions are taken management has to determine exactly how each process will be performed. This is called 'operation analysis. Operation analysis is concerned with the work content constituting the operation and method of performing the work, given the resources allocated to the process. Similar to process analysis, operation analysis generates an operation sheet. It specifies the steps and elements of work for each operation. These are specified in a

proper sequence. Together with the route sheet and operation sheet provide all the information required to perform a process effectively and efficiently.

3.14 TYPES OF PROCESSES

There are different ways to categorize a process. They can be categorized on the basis of orientation, e.g. market orientation or manufacturing process; they may also be categorized on the basis of the production methodology or customer involvement. The various type set processes are given below:

ii) **Processes by Market Orientation :**

There are four types of processes based on market orientation:

- Make to stock: The goods usually are standard, mature products. As a general rule make to stock products compete primarily on the basis of cost and availability. Example of such products includes most retail goods.
- Assemble to order: Products are standard items that are assembled from in stock subassemblies. This allows customers to specify a wide range of options.
- Make to order: are made from previous designs, but are made only after an order has been received. Make to order products are used when the standard product is too costly to stock, have too uncertain demand, or will deteriorate if stocked on shelf.
- Engineer to order: This market orientation is used to make unique products that have not been previously engineered, Extensive customization to suite the customers' need is possible but only if customer is willing to wait for this addition stage in the value creation process.

iii) **Processes as production systems:**

A production system refers to how an organization organizes material flow using different process technologies. There are five types of production systems:

- Projects: These are one-off projects. It is based on extensive customization that is suited to the customer's 'need. Many construction projects, project management contract, shipbuilding and civil engineering projects fall in this category.
- Job shop: Construction is characterized by processing of small batched of a large number of products, most of which require a different set or sequence of processing steps.

Production equipment is mostly general purpose to meet the specific customer orders.

- Batch production: Production is in discrete parts that are repeated at regular intervals. Such a structure is generally employed for relatively stable lines of products, each of which is produced in medium volume.
- Assembly Line: It is a mass production process. On assembly line, production follows in a predetermined sequence of steps which are continuous rather than discreet. The product moves from work station to workstation at a controlled rate following the sequence needed to build the product.

3.15 SUMMARY

- **Product:** A product may be defined as an item created to satisfy the need of customers. In other words, a product is an article obtained by the transformation of raw material and is saleable.
- **Product design:** The traditional starting point in the production process is designing the products or services. Decision related to design include the product features, the desires level of quality, the material to use and the resulting production costs.
- The various consideration in a good design can be grouped into three category- (1) Design requirement (2) Life- cycle issues (3) Regulatory and social issues.
- The eight steps involved in the new product namely- (1) idea generation (2) idea screening (3) concept development and testing (4) business analysis (5) marketing strategy development (6) product development (7) test marketing (8) commercialization.
- **Value engineering:** It refers to a set of activities undertaken to investigate the design of components in a designing process strictly from cost value perspective.

3.16 SELF ASSESSMENT QUESTIONS

1. Define product and its core features. Explain the components of product.
2. Discuss the methodology and tools used for the new product development evaluation.
3. Explain in detail the stages involved in product life cycle using diagram.
4. Take your own case study of an individual product with regard to an automobile product. Show the detailed product life cycle of that product and explain them in detail.

5. Explain in detail the steps involved in new product development.
6. When designing product, what are the issues that need to be considered.
7. Discuss the legal, ethical and environmental issues in designing of a product with suitable examples.
8. What are the factors that need to be considered in the process of product design and development?
9. Briefly explain value engineering.
10. Discuss the tools for mass customization.

3.16 SUGGESTED BOOKS/REFERENCES

1. Cherry. S. N., Production and Operations Management, Mc Graw Hill Education.
2. Mahajan. M., Industrial Engineering and Production Management, Dhanpat Rai & Co.
3. Chunawalla.S.A., Production and Operations Management, Himalayan Publishing House.

UNIT-4 PROFIT CONSIDERATION

Unit Structure

4.0 Unit Objectives

4.1 Profit Consideration in Product Planning and Control

4.2 Tools for Product Development and Profit Maximization

4.3 Break Even Analysis

4.4 Summary

4.5 Self Assessment Questions

4.6 Suggested Books/References

4.0 UNIT OBJECTIVES

In this chapter, a detailed description regarding profit consideration has been given along with the steps involved in profit planning and tools for product development to have a vivid understanding of the chapter.

4.1 PROFIT CONSIDERATION IN PRODUCT PLANNING AND CONTROL

Profit is considered as a significant element of a business activity. According to Peter Drucker, "Profit is a condition of survival." It is the cost of the future, the cost of staying in a business." Thus, Profit should be planned and managed properly. An organization should plan profits by taking into consideration its capabilities and resources. Profit Planning lays foundation for the future income statement of the organization. The Profit Planning Process begins with the forecasting and estimating the desired level of profit taking in view the market conditions.

The steps involved in Profit Planning Process are shown in the figure below and explained as follows:

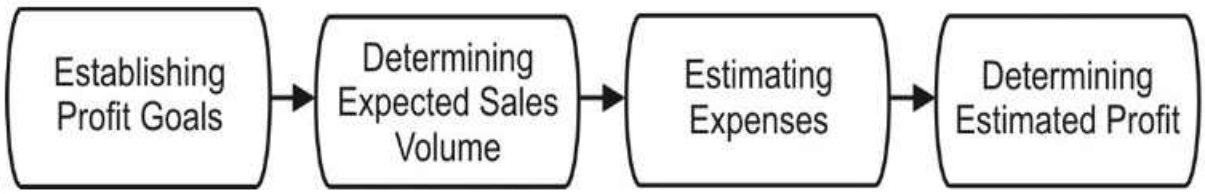


Figure : Profit Planning Process

1. **Establishing Profit goals:**

   It implies that profit goals should be set in alignment with the strategic plans of the organization. Moreover, the profit goals of an organization should be realistic in nature based on the capabilities and resources of the organization.

2. **Determining expected sales volume:**

   It constitutes the most important step of the Profit Planning Process. An organization needs to forecast its sales volume so that it can achieve its profit goals. The sales volume can be anticipated by taking into account the market and industry trends and performing competitive analysis.

3. **Estimating expenses:**

   It requires that an organization needs to estimate its expenses for the planned sales volume. Expenses can be determined from the past data. If an organization is new, then data of similar organization in same industry can be taken. The expense forecasts should be adjusted to the economic conditions of the country.

4. **Determining estimated profit:** It helps in estimating the exact value of sales.

   It is calculated as:

   Estimated Profit = Projected Sales Income – Expected Expenses

   After planning profit successfully, an organization needs to control profit. Profit control involves measuring the gap between the estimated level and actual level of profit achieved by an organization. If there is any deviation, the necessary actions are taken by the organization.

The steps involved in profit control process are explained as follows:

1. **Comparing estimates with the goal :**

   It involves comparing the estimated profit with the expected profit. If there is a large gap between the estimated profits and the expected profits, the measures should be taken.

2. **Using alternatives to achieve the desired profit:**

   a) Making changes in planned sales volume by increasing sales promotion, improving product quality, providing better service, and providing after sales support to customers.

   b) Reducing planned expenses by minimizing losses, implementing better control systems, improving product quality, and increasing the productivity of human resource and machines.

4.2 TOOLS FOR PRODUCT DEVELOPMENT AND PROFIT MAXIMIZATION

The following are various product development techniques adopted by different organizations for profit maximization:

4.2.1. STANDARDIZATION

This means fixation of some appropriate size, shape, Quality, manufacturing process, weight and other characteristics as standard to manufacture a product of desired variety and utility e.g. manufacture of television sets of standard size of the screen using standard components and technology; shaving blades are made of standard size and shape to suite every kind of razor. The concept of standardization is applicable to all factors of production namely men, materials, machines and finished goods. These standards can become the basis to evaluate the performance of various components of production in a manufacturing process. According to *Behel, Smith and Stackman:*"A standard is essentially a criterion of measurement, quality, performance, practice established by custom, consent or authority and used as a basis for comparison over a period of time. The setting of standards and the coordination of the industrial factors to comply with these standards and to maintain them during the periods for which they are effective is known as industrial standardization."

According to *Dexter S Kimball,* "Production control operation in the manufacturing sense is the reduction of any one line to fixed types, sizes and characteristics." Standardization becomes the basis of production control operations and works as a catalyst in directing and operating the working of business enterprise. It identifies and compares various products, systems and performances in an enterprise. It is the function of the department responsible for designing the product to provide the guidelines and infrastructure for standardization of the whole system keeping into consideration the designing stage towards standardization may be too expensive to be rectified.

For an organization designing of the product without considering standardization aspect is of no value of significance. *Franklin F. Folts* has described the concept of standardization as,"Simplification of product lines and concentration on a restricted predetermined variety of output is one common application of the principles of standardization may be extended to all factors in the production process". Standardization is an instrument to manufacture maximum variety of products out of minimum variety of components by means of a minimum variety of machines and tools. This decreases working capital requirements and reduction in manufacturing costs.

Standardization also implies that non-standard items are not to be manufactured except when the consumers order them specifically. Some standards are enacted by law viz. automobile windscreen which must be

made of safety glass. Usually there are institutions, societies and governmental departments that regulate the standards. In a factory, it is best to have standardization committee drawing its members from sales, engineering, production purchasing, quality control and inspection.

Sales department and engineering department have to work closely in effecting changes towards standardization because the older products that have been sold are affected for after-sales service needs. Within an organization, it is the engineering department who sets standards for the materials to be procured and specification of the end products and the mode of testing the products.

[A] Advantages of Standardization:

- Standardization in designing, purchasing of raw material, semi-finished and finished goods and of the manufacturing process tries to eliminate wastage and reduce the cost of production. Reduction in varieties of raw materials means reduced investments in stocks and less attention to stock control.
- Standardize product components reduce to old cost, permits larger and more economical lot sizes of production, avoids losses for obsolescence and reduces capital requirements for work in process.
- Production in larger quantities can be planned which results in less set-up costs.
- By minimizing the operations in production process it provides facility to introduce new mechanism and use of more specialized tools and equipments.
- Service and maintenance costs as well as marketing expenses are reduced.
- Encourages the manufacturer to products ofnew style, use and performance with an object to generate more customers.
- The value of the standardized product lying in stocks or in stocks or in transit can be easily for the purpose of advancing loans.

[B] Disadvantages of Standardization:

Product standardization leads to some disadvantages also. These are:

- Too much standardization has an adverse affect on the efficiency and morale of the workers. They in the long run feel bored and fed-up in doing the same routine again.

- The spirit of challenge and initiative vanishes with passage of time.
- During the initial process of product Development where frequent improvements and changes may be necessary to bring the product and production process up to the mark, standardization may create obstacles in innovations.
- For small scale enterprises standardization may not be advantageous.

4.2.2 SIMPLIFICATION

In production, simplification can be done at two places namely for product and for work. Simplification in product development is used for products; In fact, simplification should be done before standardization.

In the words of *F. Clark and Carrie*, "Simplification in an enterprise connotes the elimination of excessive and undesirable or 'marginal lines' of product to hammer out waste and to attain economy connotes the elimination of excessive and undesirable or marginal lines of product to hammer out waste and to attain economy coupled with the main object of improving quality and reducing costs and prices leading to increased sales."

W.R Spiegel and R.H Lansburg also defines, "Simplification refers to the elimination of superfluous varieties, size dimensions etc." Simplification can be advantageous to both producer and the consumer of a product.

[A] Advantages of Simplification :

- Eliminates surplus use of materials to provide economy in production cost. More production increases the inventory size which avoids delays in supply.
- Less obsolescence of materials and machinery.
- Due to simplification in operation the efficiency of the production process increase and this leads to more productive due to scope of better training and learning facility with simplification operation.
- Human efforts become more productive due to scope of better training and learning facility with simplified operation.
- After-sales service prospects are minimized.
- Production planning and control operations become easy and simple.
- Reduction in cost of production leads to more sales.
- To jobber-wholesalers and Retailers.

- Increased turn over.
- Sales effort on fewer items.
- Reduction in storage space.
- Less overheads and handling expenditures.

4.2.3 SPECIALIZATION

Specialization implies expertise in some particular area or field. It is experienced that as the companies expand the range of their products, manufacturing system involves more and operations for transforming inputs into output. This often result an increase in operation cost and decline profits. The problem can be solved by identifying the products contributing to losses and then eliminate their production. This will lead to confine the production of profitable items only and consequently a reduction in number of operation required in the process. The minimization of operation can lead to use of expert knowledge, skill and techniques in production system, the nature and the type of product. Operation required manufacturing it and the nature of the market. Specialization implies reduction in the variety of products manufacturing by the organization.

[A] Advantages of Specialization :

- Specialization and standardization leads to higher productivity.
- Incase in output and reduction in per unit cost of production.
- Savings in purchase of raw material and improvement in the quality of the finished goods.

[B] Disadvantages of Specialization :

- Less flexibility in adjustment to changed situations.
- Monotony and boredom may adversely affect the efficiency.

4.2.4 DIVERSIFICATION

It implies policy of producing different types of products by an enterprise. Thus it is reverse of simplification are associate with the nature of the industry e.g. in the case of capital goods industry simplification is more important as the customers give preference to economy, accuracy and performance of the product, whereas in an consumer goods industry diversification leads to produce variety of goods in ;terms of style, shape, color, design etc.

The establishment facing tough competition is forced to diversify this activates to capture the market. In general diversification can be adopted for the purpose of:-

(a) Utilization of idle/surplus resources

(b) Stabilization of sales

(c) To cope with demand fluctuations

(d) For survival of the organization.

Due care and precautions should be taken in the formulation of diversification policy. Proper and extensive market analysis at different levels of the quality and quantity of the products should be done to determine the levels of profitability. This will help in the selection of the most appropriate diversification strategy under the prevailing circumstances.

[A] Advantages of Diversifications

- Increase in sales due to production of different kind of products. This also leads to increase in volume of business.
- Needs of wider section of consumer are fulfilled.
- 'Risk minimization' in the case of quick and unpredictable demand variations. Uniform and balanced production programme can be chalked out without any consideration of wastage by production by products.
- Elimination of wastage by producing by-products.

[B] Disadvantages of Diversifications

- Due to increase in number of operations the production process becomes quite complicated and some times expensive.
- Production Planning and control operation becomes complicated and time consuming requiring extra efforts.
- The size and the variety of items in; the inventory increases with diversification introducing more problems.
- Worker of different types of skill and expertise are required.

4.3 BREAK EVEN ANALYSIS

One of the most common tools used in evaluating the economic feasibility of a new enterprise or product is the break-even analysis. The break-even point is the point at which revenue is exactly equal to costs. At this point, no profit is made and no losses are incurred. The break-even point can be expressed in terms of unit sales or dollar sales. That is, the break-even units indicate the level of sales that are required to cover costs.

Sales above that number result in profit and sales below that number result in a loss. The break-even sales indicate the dollars of gross sales required to break-even. It is important to realize that a company will not necessarily produce a product just because it is expected to breakeven. Many times, a certain level of profitability or return on investment is desired. If this objective cannot be reached, which may mean selling a substantial number of units above break-even, the product may not be produced. However, the break-even is an excellent tool to help quantify the level of production needed for a new business or a new product. Break-even analysis is based on two types of costs: fixed costs and variable costs. Fixed costs are overhead-type expenses that are constant and do not change as the level of output changes. Variable expenses are not constant and do change with the level of output. Because of this, variable expenses are often stated on a per unit basis. Once the break-even point is met, assuming no change in selling price, fixed and variable cost, a profit in the amount of the difference in the selling price and the variable costs will be recognized. One important aspect of break-even analysis is that it is normally not this simple. In many instances, the selling price, fixed costs or variable costs will not remain constant resulting in a change in the break-even. And these changes will change the break-even. So, a break-even cannot be calculated only once. It should be calculated on a regular basis to reflect changes in costs and prices and in order to maintain profitability or make adjustments in the product line.

There are three basic pieces of information needed to evaluate a break-even point:

Average per Unit Sales Price: _____

Average per Unit Variable Cost: _____

Average Annual Fixed Costs: _____

The basic equation for determining the break-even units is:

Average Annual Fixed Cost ÷ (Average per Unit Sales Price - Average per Unit Variable Cost)

The basic equation for determining the break-even sales:

Annual Fixed Cost ÷ 1 - (Average per Unit Variable Cost ÷ Average per Unit Sales Price)

Break-even analysis can be very helpful in the evaluation of a new venture. In most instances, success takes time. Many new enterprises and products actually operate at a loss (at a point below break-even) in the early stages of development. Knowing the price or volume necessary to break-even is critical to evaluating the time-frame in which losses are permissible. The break-even is also an excellent benchmark by which a company's short-term goals can be measured/ tracked. Break-even analysis mandates that costs be analyzed. It also keeps a focus on the connection between production and marketing.

Example : A local livestock producer utilizes compost waste to develop an organic fertilizer product. The fertilizer is prepared for retail sale in 50 pound bags. The retail sales price is $5.00 per bag. The average variable cost per bag is $2.80 and average annual fixed costs are $60,000. These three pieces of information are:

Average per Unit Sales Price = $5.00 per bag

Average per Unit Variable Cost = $2.80 per bag

Average Annual Fixed Costs = $60,000.00

The above assumption can be utilized to calculate the number of bags that must be sold in order to break-even as well as the total dollar of sales needed to break-even. Using the formulas explained earlier, the following calculations can be made:

Break-Even Units: $60,000.00 ÷ ($5.00 - $2.80) = 27,273 bags

Break-Even Sales: $60,000.00 ÷ 1 - ($2.80 ÷ $5.00) = $136,365

Therefore, no profits are made from the sale of this product until more than 27,273 bags are sold or more than $136,365 in gross sales is generated.

4.4 SUMMARY

- Profit Planning lays foundation for the future income statement of the organization. The profit planning process begins with the forecasting and estimating the desired level of profit taking in view the market conditions.
- The steps involved in profit planning process are (1) establishing profit goals (2) determining expected sales volume (3) estimating expenditure (4) determining estimated profit.
- Tools used for product development and profit maximization are- standardization, simplification, diversification and specialization.
- Standardization: This means fixation of some appropriate size, shape, quality, manufacturing process, weight and other characteristics as a standard to manufacture a product of desired variety and utility.
- Simplification: simplification in an enterprise connotes the elimination of excessive and undesirable or marginal lines of product to improve quality.
- Specialization: It implies expertise in some particular area or field.
- Breakeven point: It is one of the tools used in evaluating the economic feasibility of a new enterprise or product. The BEST is

the point at which revenue is exactly equal to cost. At this point no profit is made and no losses are incurred.

4.5 SELF ASSESSMENT QUESTIONS

1. Explain in detail the steps involved in profit planning process.
2. What are the product development tools. Explain in detail.
3. What is specialization? How does it differ from diversification?
4. Explain Standardization. Discuss its advantages and disadvantages.
5. What is Break Even Analysis? How is it calculated?
6. Explain in detail the application of Break Even Analysis.

4.6 SUGGESTED BOOKS/ REFERENCES

1. Cherry. S. N., Production and Operations Management, Mc Graw Hill Education.
2. Mahajan. M., Industrial Engineering and Production Management, Dhanpat Rai & Co.
3. Chunawalla.S.A., Production and Operations Management, Himalayan Publishing House.

Uttar Pradesh Rajarshi Tandon Open University

Master of Business Administration

MBA-3.34

Production, Planning and Control

BLOCK

2

WORK STUDY

UNIT-5

Method Study

UNIT-6

Motion Study

UNIT-7

Work Measurement

परिशिष्ट–4

आन्तरिक कवर–दो का प्ररूप

Format of the II Inner Covers

लेखक Dr. Ekta Verma, Asst. Professor MONIRBA University of Allahabad, Prayagraj

सम्पादक Prof. J.N. Bhargawa, MONIRBA, University of Allahabad, Prayagraj.

परिमापक

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UNIT-5 METHOD STUDY

Unit Structure

5.0 Unit Objectives

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5.2 Foundation of Work Study

5.3 Advantages of Work Study

5.4 Importance /Objectives of Work Study

5.5 Application of Work Study to Office Work

5.6 Relationship between Method Study and Work Measurement

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5.0 UNIT OBJECTIVES

The objective of this unit is to provide a detailed information about method study its advantages, scope and objectives. It also explain the detailed procedure involved in method study.

5.1 INTRODUCTION

Work study is a generic term for those techniques, method study and work measurement which are used in the examination of human work in all its contexts. And which lead systematically to the investigation of all the factors which affect the efficiency and economy of the situation being reviewed, in order to effect improvement. Work study concerns itself with better ways of doing things and control over the output of those things by setting standards with respect to time. Productivity which is generally speaking, a ratio of output to input, is of great importance for the smooth running of any organization, it assumes particular importance for developing countries like India who have compete favourably with other countries in the international market and make optimal use of scarce resources. Although usually the concepts of Work Study relate to a manufacturing organization, they are equally valid for other than manufacturing situations where services – if not goods are generated.

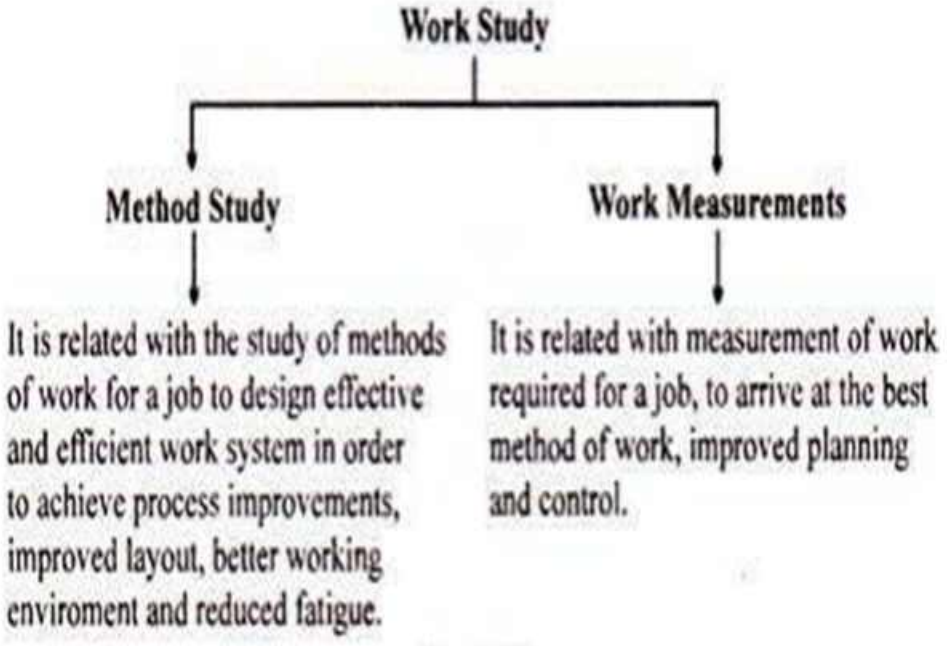


Figure 5.1 : Components of Work study

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

5.2 FOUNDATION OF WORK STUDY

In fact, early researchers in the field of management were concerned with Motion Study. Frederick W. Taylor, Frank B. Gilbreth and Lillian M. Gilbreth were some of the pioneers in the field of work study. Dr. Taylor's conclusion was: "The greatest production results when each worker is given a definite task to be performed in a definite time in a definite manner". This is the foundation on which modern Work Study stands today.

The implication in the above statement of the interrelationship between Method and Time Studies is important. By knowing the method you may improve the overall time, and by the study of the time taken for the different component tasks involved in the method you may get leads to improve the method.

5.3 ADVANTAGES OF WORK STUDY

Following are the advantages of work study:

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

5.4 IMPORTANCE /OBJECTIVES OF WORK STUDY

The main concern of work study is to improve productivity of existing jobs and maximize productivity in the design of future jobs within constraints. Work study helps to reduce waste through standardization of qualitative quantitative elements of a job. It aids in increasing industrial productivity through standardization. Following are the importance of work study

- It is a means for raising productivity of an industry by re - organisation of the work, involving little or no capital expenditure at all.
- It is used to determine the standards of performance on which effective planning and control depends.
- It follows a systematic approach which ensures no related factor is overlooked.
- It results in better workplace layout, neat and clean working environment resulting in minimum movement of workers and materials.
- It results in saving and efficient use of human and material resources by increasing output and reducing scrap, rework etc.
- It eliminates unnecessary human movements.
- Results in improved safety.
- Reduction in fatigue and health hazard.
- It guides to determine the level of skill in the workers for implementing the incentive based wage system.
- It helps to minimize unit cost by proper selection and use of machine, processes etc.

5.5 APPLICATION OF WORK STUDY TO OFFICE WORK

The principles and techniques of Work Study have been applied to office work also, although with some difficulties. The difficulties are arguably to the following:

- Office work involves a significant portion of "mental work". This refers to the decision making process involved and "creative thinking" involved in the problem- solving which is difficult to measure in terms of time.
- Office work is irregular and non- repetitive in nature, unlike the manufacture of a product in a factory. It is possible to visualize an office Assistant or a Secretary doing a variety of jobs in variety of permutations and combinations at different times. At one time he/she is making a decision, at another leafing through an office communication, and yet another talking to a potential customers, etc.

  In short, it is argued and justifiably so, that office work is less amenable to accurate measurement. But much accuracy may not really be necessary and generally ball- park standards of work may

be quite adequate. Moreover, not all the above arguments hold much water on closer scrutiny. For instance, in the work of a clerk, the mental work component or decision- making component may not be considerable. For this, much of the irregular office work can be made more regular by proper planning and supervision. Work measurement is usually required to investigate whether a section of the office is understaffed or overstaffed and to provide guidelines for future manpower planning, for this purpose a rather broad based and less precise work measurement would be adequate.

5.6 RELATIONSHIP BETWEEN METHOD STUDY AND WORK MEASUREMENT

- **Method Study:** Method study is the systematic recording and critical examination of existing and proposed ways of doing work, as a means of developing and applying easier and more effective methods and reducing costs.
- **Work Measurement:** Work Measurement is the application of techniques designed to establish time for a qualified worker to carry out a specified job at a defined level of performance.

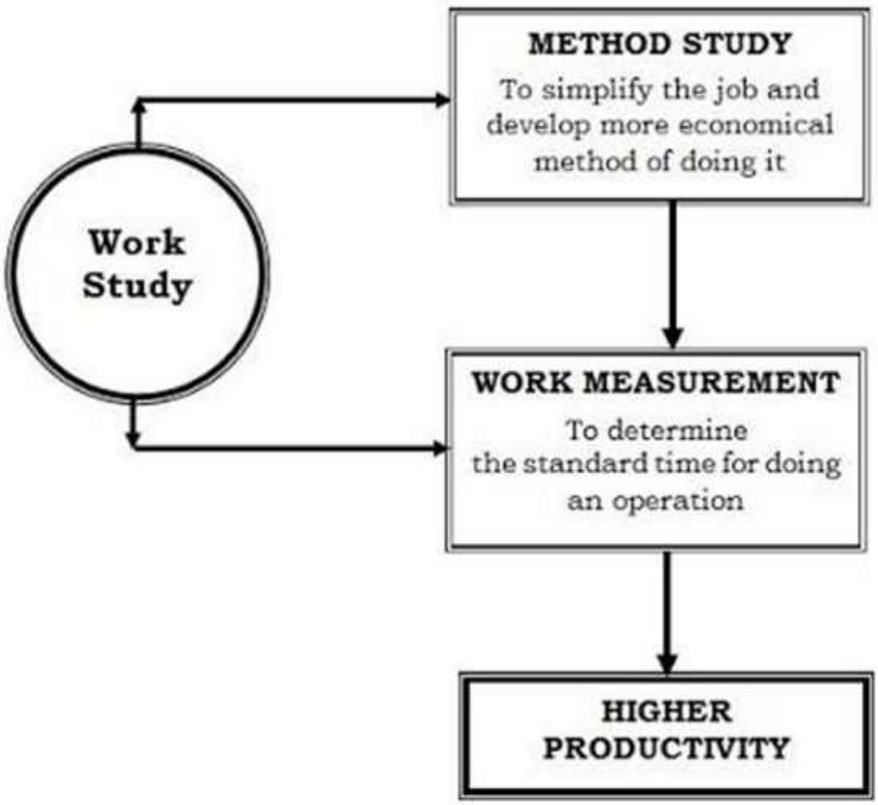


Figure 5.6 : Relationship between method study and work measurement.

5.7 METHOD STUDY

Method study enables the industrial engineer to subject each operation to systematic analysis. The main purpose of method study is to eliminate the unnecessary operations and to achieve the best method of performing the operation.

Method study is also called methods engineering or work design. Method engineering s used to describe collection of analysis techniques which focus on improving the effectiveness of men and machines.

According to British Standards Institution (BS 3138): *"Method study is the systematic recording and critical examination or existing and proposed ways or doing work as a means or developing and applying easier and more effective methods and reducing cost."*

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

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

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

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

5.8 OBJECTIVES OF METHOD STUDY

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

The improvement in efficiency is achieved through:

1. Improved layout and design of workplace.
2. Improved and efficient work procedures.

3. Effective utilisation of men, machines and materials.
4. Improved design or specification of the final product.

The objectives of method study techniques are:

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

5.9 SCOPE OF METHOD STUDY

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

The areas to which method study can be applied successfully in manufacturing are:

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

5.10 PRE-REQUISITES FOR METHOD STUDY

Following are the pre-requisites for method study:

- Aim of the investigation giving a scope of study and special limitations to be observed.
- Results to be expressed.
- Expected time and cost of investigation.
- Basis of survey estimates indicating present situation.
- Programme of investigation techniques required.

5.11 STEPS OR PROCEDURE INVOLVED IN METHODS STUDY

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

Figure : Procedure of method study

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

4. **DEVELOP** the most practical, economic and effective method, drawing on the contributions of those concerned.

5. **EVALUATE** different alternatives to developing a new improved method comparing the cost-effectiveness of the selected new method with the current method with the current method of performance.

6. **DEFINE** the new method, as a result, in a clear manner and present it to those concerned, *i.e.*, management, supervisors and workers.

7. **INSTALL** the new method as a standard practice and train the persons involved in applying it.

8. **MAINTAIN** the new method and introduce control procedures to prevent a drifting back to the previous method of work.

5.12 SELECTION OF THE JOB FOR METHOD STUDY

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

(*a*) Improvement in quality with lesser scrap.

(*b*) Increased production through better utilisation of resources.

(*c*) Elimination of unnecessary operations and movements.

(*d*) Improved layout leading to smooth flow of material and a balanced production line.

(*e*) Improved working conditions.

5.13 CRITERIA FOR METHODS IMPROVEMENT

- Improved cost performance,
- Improved time or delay performance,
- Improved worker satisfaction,
- Improved standardization of operations and products.

5.14 CONSIDERATIONS FOR SELECTION OF METHOD STUDY

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

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

A. Economic Aspects

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

(*a*) Bottleneck operations which are holding up other production operations.

(*b*) Operations involving excessive labour.

(*c*) Operations producing lot of scrap or defectives.

(*d*) Operations having poor utilisation of resources.

(*e*) Backtracking of materials and excessive movement of materials.

B. Technical Aspects

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

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

C. Human Considerations

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

1. Workers complaining about unnecessary and tiring work.
2. More frequency of accidents.
3. Inconsistent earning.

5.15 RECORDING TECHNIQUES FOR METHOD STUDY

The next step in basic procedure, after selecting the work to be studied is to record all facts relating to the existing method. In order that the activities selected for investigation may be visualised in their entirety and in order to improve them through subsequent critical examination, it is

essential to have some means of placing on record all the necessary facts about the existing method. Records are very much useful to make before and after comparison to assess the effectiveness of the proposed improved method. The recording techniques are designed to simplify and standardise the recording work. For this purpose charts and diagrams are used.

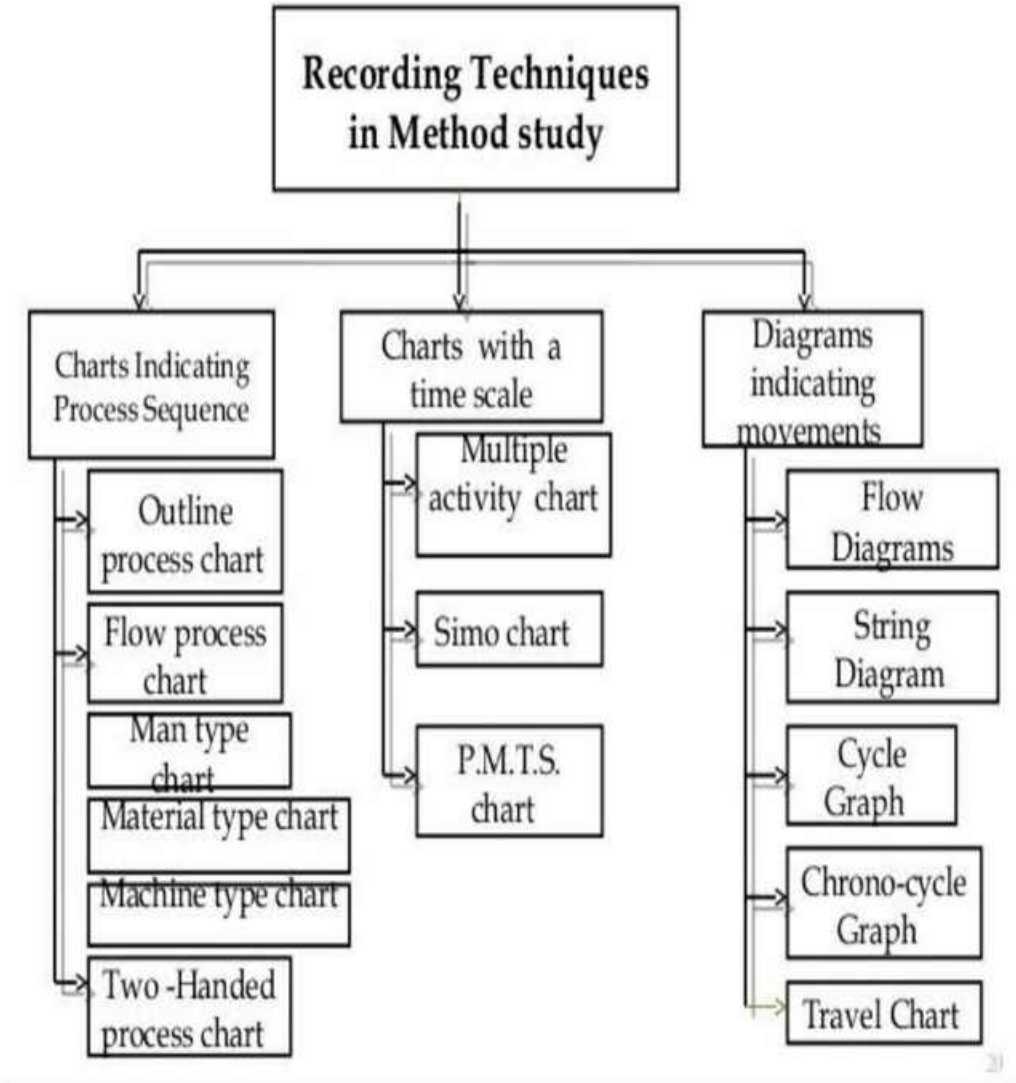


Figure 5.15 : Recording techniques for method study

5.16 CHARTS USED IN METHOD STUDY

This is the most popular method of recording the facts. The activities comprising the jobs are recorded using method study symbols. A great care is to be taken in preparing the charts so that the information it shows is easily understood and recognized. The following information

should be given in the chart. These charts are used to measure the movement of operator or work (*i.e.*, in motion study).

(*a*) Adequate description of the activities.

(*b*) Whether the charting is for present or proposed method.

(*c*) Specific reference to when the activities will begin and end.

(*d*) Time and distance scales used wherever necessary.

(*e*) The date of charting and the name of the person who does charting.

5.17 TYPES OF CHARTS

It can be broadly divided into (A) Macro motion charts and (B) Micro motion charts.

Macro motion charts are used for macro motion study and micro motion charts are used for micro motion study. Macro motion study is one which can be measured through 'stop watch' and micro motion study is one which cannot be measured through stop watch.

(A) MACRO MOTION CHARTS

Following four charts are used under this type:

1. Operation Process Chart

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

(*a*) Visualise the complete sequence of the operations and inspections in the process.

(*b*) Know where the operation selected for detailed study fits into the entire process.

(*c*) In operation process chart, the graphic representation of the points at which materials are introduced into the process and what operations and inspections are carried on them are shown.

2. Flow Process Chart

Flow process chart gives the sequence of flow of work of a product or any part of it through the work centre or the department recording the events using appropriate symbols. It is the amplification of the operation process chart in which operations;

inspection, storage, delay and transportation are represented. However, process charts are of three types:

(*a*) Material type - Which shows the events that occur to the materials.

(*b*) Man type- Activities performed by the man.

(*c*) Equipment type- How equipment is used.

The flow process chart is useful:

(*a*) To reduce the distance travelled by men (or materials).

(*b*) To avoid waiting time and unnecessary delays.

(*c*) To reduce the cycle time by combining or eliminating operations.

(*d*) To fix up the sequence of operations.

(*e*) To relocate the inspection stages.

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

3. Two Handed Process Chart

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

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

4. Multiple Activity Chart

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

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

5.18 DIAGRAMS USED IN METHOD STUDY

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

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

Diagrams are of two types:

1. Flow diagram and
2. 2.String diagram.

1. FLOW DIAGRAM

Flow diagram is a drawing, of the working area, showing the location of the various activities identified by their numbered symbols and are associated with particular flow process chart either man type or machine type.

The routes followed in transport are shown by joining the symbols in sequence by a line which represents as nearly as possible the path or movement of the subject concerned.

Following are the procedures to make the flow diagram.

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

2. STRING DIAGRAM

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

seeing what is actually taking place is made as simple as possible. One of the most valuable features of the string diagram is the actual distance travelled during the period of study to be calculated by relating the length of the thread used to the scale of drawing. Thus, it helps to make a very effective comparison between different layouts or methods of doing job in terms of the travelling involved.

The main advantages of string diagram compared to flow diagram is that respective movements between work stations which are difficult to be traced on the flow diagram can be conveniently shown on string diagram.

Following are the procedures to draw string diagram:

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

5.19 SYMBOLS USED IN METHOD STUDY

Graphical method of recording was originated by Gilbreth, in order to make the presentation of the facts clearly without any ambiguity and to enable to grasp them quickly and clearly. It is useful to use symbols instead of written description. The below image shows a list of different symbols used for recording the facts:

Figure : Symbols used in method study

Operation : When an object is intentionally changed in one or more of its physical or chemical characteristics operation occurs. It includes the main steps involved in a process, method or procedure. An operation always takes the object one stage ahead towards completion. Some examples of operation are:

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

Inspection : When an object is critically examined and compared with the standard for quality and quantity, an inspection occurs. Some examples of inspection are:

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

Transportation : When there is a movement of workers, materials or equipment from one place to another, it is termed as transportation. Some examples of transportation are:

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

Delay : When the immediate performance of the next planned thing/process does not take place, a delay occurs. Some examples of delay are:

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

Storage : Indicates a controlled storage in which a material is issued or received from the store under some form of authorization, or an item is retained for reference purposes. Some examples of storage are:

- Raw material in bulk storage.
- Finished stock stacked on pallets.
- Protective filing of documents.

5.20 SUMMARY

- Work study is a means of enhancing the production efficiency (productivity) of the firm by elimination of waste and unnecessary operations. It is a technique to identify non value adding operations by investigation of all the factors affecting the job. It is the accurate and systematic procedure oriented technique to establish time standards.
- Method study and work measurement is a part of work study.
- Method study enables the industrial engineer to subject each operation to systematic analysis. The main purpose of method study is to eliminate the unnecessary operation and to achieve the best method of performing the operation.
- The basic approach to method study consists of eight steps namely- selecting, recording, examining, developing, measuring, defining, installing and maintaining.
- Economic aspects, technical aspects and human aspects are the considerations for the selection of method study.
- Two types of chart used in method study are (a) Macro motion chart (b) micro motion chart.
- Macro motion study is one which can be measured through 'stopwatch' and micro motion study is one which cannot be measured through stopwatch.
- Flow diagram and string diagram are used in method study to show the sequence and nature of movement.

5.21 SELF ASSESSMENT QUESTIONS

1. What is work study? What are the various components of work study?
2. List out the application and benefits of work study.
3. Give an overview of method study. Explain its objectives and scope.
4. Explain in detail the steps / procedure involved in method study.
5. Discuss the economic, technical, human consideration for the selection of method study.
6. What are the recording techniques for method study.
7. What are the various symbols and diagrams that are used in method study?
8. Describe in detail the types of charts used in method study.

5.22 SUGGESTED BOOKS / REFERENCES

1. Chary S. N., Production and Operations Management, Mc Graw Hill Education.

2. Mahajan M., Industrial Engineering and Production Management, Dhanpati Rai &Co.

3. Chunawalla.S.A., Production Operations and Management, Himalaya Publishing House.

UNIT-6 MOTION STUDY

Unit Structure

6.0 Unit Objectives

6.1 Introduction

6.2 Principles of motion study

6.3 Micro Motion Study

6.4 Purpose of Micro Motion Study

6.5 Advantages of micro motion study

6.6 Micro Motion Study chart

6.7 Memo Motion Study

6.8 Field of application of memo motion study

6.9 Summary

6.10 Self assessment question

6.11 Suggested Books/ References

6.0 UNIT OBJECTIVES

This unit provides a clear understanding of development, implementation of motion study. It also explains micro motion and memo motion study, its importance, merits and demerits.

6.1 INTRODUCTION

Motion study is a technique of analysing the body motions employed in doing a task in order to eliminate or reduce ineffective movements and facilitates effective movements. By using motion study and the principles of motion economy the task is redesigned to be more effective and less time consuming.

The Gilbreth pioneered the study of manual motions and developed basic laws of motion economy that are still relevant today. They were also responsible for the development of detailed motion picture studies, termed as ***Micro Motion Studies***, which are extremely useful for analysing highly repetitive manual operations. With the improvement in technology, of course, video camera has replaced the traditional motion picture film camera.

In a broad sense, motion study encompasses micro motion study and both have the same objective i.e. job simplification so that it is less fatiguing and less time consuming. While motion study involves a simple

visual analysis, micro motion study uses more expensive equipment. The two types of studies may be compared to viewing a task under a magnifying glass versus viewing the same under a microscope. The added detail revealed by the microscope may be needed in exceptional cases when even a minute improvement in motions matters, i.e. on extremely short repetitive tasks.

Taking the cine films @ 16 to 20 frames per second with motion picture camera, developing the film and analysing the film for micro motion study had always been considered a costly affair. To save on the cost of developing the film and the cost of film itself, a technique was used in which camera took only 5 to 10 frames per minute. This saved on the time of film analysis too. In applications where infrequent shots of camera could provide almost same information, the technique proved fruitful and acquired the name ***Memo Motion Study***.

6.2 PRINCIPLES OF MOTION STUDY

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

The principles are grouped into three headings:

(A) Use of the human body.

(*B*) Arrangement of workplace.

(*C*) Design of tools and equipment.

(A) Use of human body

When possible:

1. The two hands should begin and complete their movements at the same time.
2. The two hands should not be idle at the same time except during periods of rest.
3. Motions of the arms should be made simultaneously.
4. Hand and body motions should be made at the lowest classification at which it is possible to do the work satisfactorily.
5. Momentum should be employed to help the worker, but should be reduced to a minimum whenever it has to be overcome by muscular effort.

6. Continuous curved movements are to be preferred to straight line motions involving sudden and changes in directions.

7. 'Ballistic' (*i.e.*, free swinging) movements are faster, easier and more accurate than restricted or controlled movements.

8. Rhythm is essential to the smooth and automatic performance of a repetitive operation.

   The work should be arranged to permit easy and natural rhythm wherever possible.

9. Work should be arranged so that eye movements are confined to a comfortable area, without the need for frequent changes of focus.

(B) Arrangement of the work place

1. Definite and fixed stations should be provided for all tools and materials to permit habit formation.

2. Tools and materials should be pre-positioned to reduce searching.

3. Gravity fed, bins and containers should be used to deliver the materials as close to the point of use as possible.

4. Tools, materials and controls should be located within a maximum working area and as near to the worker as possible.

5. Materials and tools should be arranged to permit the best sequence of motions.

6. 'Drop deliveries' or ejectors should be used wherever possible, so that the operative does not have to use his hands to dispose of finished parts.

7. Provision should be made for adequate lightening, and a chair of type and height to permit good posture should be provided. The height of the workplace and seat should bearranged to allow alternate standing and seating.

(C) Design of tools and equipment

1. The colour of the workplace should contrast with that of work and thus reduce eye fatigue.

2. The hands should be relieved of all work of 'holding' the work piece where this can be done by a jig or fixture or foot operated device.

3. Two or more tools should be combined where possible.

4. Where each finger performs some specific movement, as in typewriting, the load should be distributed in accordance with the inherent capacities of the fingers.

5. Handles such as those used on screw drivers and cranks should be designed to permit maximum surface of the hand to come in contact with the handle.

6. Levers cross bars and wheel bars should be in such position that operator can manipulate them with least body change and with greatest mechanical advantage.

6.3 MICRO MOTION STUDY

Micro motion study technique is best suited for those operations or activities which are of short duration and which are repeated hundreds of time. These are the operations or motions which require very small time and it is quite difficult to measure time for these motions accurately and the time required by these motions cannot be neglected due to repetitive operations.

In such activities it is interesting to go into greater details in order to find out which movement and effort can be avoided. All this is done to develop the best possible pattern of movement so that the operator can perform the operations repeatedly with a minimum effort and fatigue.

"Thus micro motion study is the technique of recording and analysing the timing of basic elements of an operation with the objective of achieving the best method of performing the operation." Such respective short duration activities involve quick movement of limbs which cannot be accurately studied and timed using two handed process charts. This is due to the fact that such record microscopic details such as different operation, Inspection and transport etc. Study of such microscopic movements in short cycle repetitive jobs is not sufficient.

Short cycle operations require to be studied for microscopic motions e.g., operation of picking up a nut from bin and its fixing consists of three hand motions namely reach for the nut, grasp nut and move hand back to assembly position. Such detailed analysis help to develop the best possible pattern of movements and hence enabling the operator to perform various operations repeatedly with minimum effort and fatigue.

Micro motion study is one of the most accurate techniques of work analysis used for work improvement. It makes use of motion pictures of the different activities or movement, so with the help of camera. Very small time up to 0.0005 minute can be measured and recorded by this system.

When picture camera is utilized, the procedure is known as "MICRO-MOTION STUDY". The motion time data from the film is

transferred to simo chart. The simo chart data can be further analysed for the purpose of work place layout or method improvement.

This technique was developed by Fran Gilbreth who considered that an operation consists of minute elements which may be repetitive or non-repetitive. He termed these elements THERBLIG (after his name Gilbreth if spelt back word is Therblig).

6.4 PURPOSE OF MICRO MOTION STUDY

The purpose of Micro Motion Study is to assist in finding out the most efficient way of doing work. It also train the individual operator regarding the motion principles and help in collecting the motion time data for synthetic time standards.

1. To study the nature and path of movements for obtaining the elements of an operation.
2. To study the activities of the machine and the operator.
3. To impart training to the workers or operators regarding motion; economy so that unnecessary movement by the workers may be avoided.
4. To study the relationship between the activities of operator and the machine.
5. To keep permanent record of the most efficient way of performing a task for future reference.
6. To obtain motion time data for developing synthetic time standards for various elements.
7. For carrying out research in the field of method and time study.

6.5 ADVANTAGES OF MICRO MOTION STUDY

Micro Motion Study has following important advantages:

1. It provides a permanent record of motion study on films.
2. A large number of operators can see the procedure at any time even after the completion of motion study work.
3. Films can easily reveal the difference between the present and the proposed technique.
4. Films can be demonstrated to large work force at any desired speed.
5. It provides very accurate time for each operation or motion in comparison to stop watch time study.

6. It helps in making detailed and accurate analysis of the prevailing technique.

6.6 MICRO-MOTION STUDY CHART

Micro-motion study provides a technique for recording and timing an activity. It is a set of techniques intended to divide the human activities in a groups of movements or micro-motions

(Called Therbligs) and the study of such movements helps to find for an operator one best pattern of movements that consumes less time and requires less effort to accomplish the task. Therbligs were suggested by Frank O. Gilbreth, the founder of motion study. Micro-motion study was mainly employed for the job analysis. Their other application includes:

1. as an aid in studying the activities of two or more persons on a group work?

2. as an aid in studying the relationship of the activities of the operator and the machine as a means of timing operations.

3. as an aid in obtaining motion time data for time standards.

4. Acts as permanent record of the method and time of activities of the operator and the machine.

Fig: SIMO Chart symbols

Sl. No.	***Code***	***Name***	***Description***	***Colour***
1.	SH	SEARCH	Locate and article	Black
2.	F	FIND	Mental reaction at end of search	Grey
3.	ST	SELECT		Light Grey
4.	G	GRASP	Selection from a member	Red
5.	H	HOLD	Taking hold	Gold Ochre
6.	TL	TRANSPORTED	Prolonged group	Green
		LOADED	Moving an article	
7.	P	POSITION		Blue
8.	A	ASSEMBLER	Placing in a definite location	Violet
9.	U	USE		Purple
			Putting parts together	

10.	DA	DISASSEMBLE	Causing a device to perform its functions	Light violet
11.	I	INSPECT	Separating parts	Burnt ochre
12.	PP	PREPOSITION	Examine or test	Pale blue
13.	RL	RELEASE LOAD	Placing an article ready for use	Carmine red
14.	TE	TRANSPORT EMPTY	Release an article	Olive green
15.	R	REST	Movement of a body member	Orange
16.	JD	UNAVOIDABLE DELAY		Yellow
17.	PN	PLAN	Pause to overcome fatigue	_____
			Idle- outside persons control	
			Mental plan for future action	

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

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

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

SIMO Chart

Simultaneous motion cycle chart (SIMO chart) is a recording technique for micro-motion study. A SIMO chart is a chart based on the film analysis, used to record simultaneously on a common time scale the Therbligs or a group of Therbligs performed by different parts of the body of one or more operators. It is the micro-motion form of the man type flow process chart. To prepare SIMO chart, an elaborate procedure and use of expensive equipment are required and this study is justified when the saving resulting from study will be very high.

6.7 MEMO MOTION STUDY

Memo-Motion is the technical term describing a specialized branch of photography applied to Work Study, that of taking photographs at fixed intervals, to record information about an operation or process» A 16 mm, cine camera is most often used, with some form of modification or attachment to produce spaced shots, Memo-Motion is a comparatively recent innovation, being first applied in America during 1946.

6.8 FIELD OF APPLICATION OF MEMO MOTION STUDY

1) ***Single Operator Repetition Work***, formerly the field in which Micro-motion Study was used as a recording medium. Memo-Motion Study can be used on cycles above half a minute and has particular advantages when the cycle exceeds four minutes, the maximum time 100 feet of film lasts at l6 frames per second.

2) ***Area Studies***, the study of a group of men, or machines, or both, working in an area which can be covered by the camera.

3) ***Utilization Studies***, the evaluation of the utilization of men or machines, either by long regular interval shots, or randomized shots.

4) ***Work Measurement***, setting up time standards for jobs, or compilation of Synthetic Time Data, Determination of Contingency or Process Allowances.

(A) Advantages of Memo Motion Study

As a versatile tool of work study Memo Motion Study provides following advantages :

- It enables all the advantages of film study to be obtained at a fraction of the cost of normal filming. This statement must be qualified by stating that very short cycles may warrant the use of higher frame speeds than are obtainable with Memo-Motion equipment.
- It permits cycles of longer duration than four minutes to be filmed continuously. One hundred feet of film will last 34 minutes at 2 frames per second, and this speed will supply all the relevant information required for the analysis of cycles exceeding one or two minutes.
- It extends the use of the cine-camera into a field far exceeding its previous limited scope.
- It draws attention to major movements which do not follow Gilbreth principles. In a study of a continuous

nature the projection of a Memo-Motion film at normal speeds will focus attention on bad movements, because they appear as rapid, jerky, motions on the screen, whereas they may pass unnoticed under visual observation of the actual operation.

- It appears to be easier to install than either stopwatch time study or cine-photography, because of a more favourable attitude towards it from both management and men, Managements seemed to consider that the Memo-Motion camera is a more practical instrument than the normal cine-camera.

- It provides work Study engineers with a more convenient means of convincing management that a certain operation or department is in need of improvement than is offered by the usual charts or diagrams.

- Memo-Motion studies can be made on an operation or area without previously defining the particular aspect to be observed since the nature of the error involved is not always known. This is especially true in the case of area studies, where the causes of low productivity can vary tremendously.

(B) Disadvantages of Memo motion study

There are following disadvantages of Memo Motion Study :

- It is not always possible to position the camera where it can cover the whole area to be studied. This is partly because the lenses obtainable for 16mm cameras have a long focal length in relation to the size of film, and hence a wide angle of view cannot be achieved.

- When a fairly large area is being studied, even at half second intervals, the film is too small to capture details of the hand movements of operators in the background, this means that if detailed studies are required of the movements made by individual operators in a large section, they must be studied separately or in small groups.

- If the intervals between frames are too long, it is difficult to tell from the film what type of motion, if any, is occurring.

- Utilization Studies of machines or personnel, which use long regular intervals between frames, or random shots, can only show if a machine is running or not, and have no way of recording why a machine is not running. In

some cases it may be possible to derive this information from the film, but generally it is not possible to distinguish between avoidable and unavoidable delay.

- Memo-Motion films cannot be used for rating as well as analysis, and recording purposes, as Micro-Motion films sometimes are. This is not a major disadvantage, since rating is not usually required until well after the existing method has been studied and analysed, and a new method installed.

6.9 SUMMARY

- Motion study is a technique of analysing the body motions employed in doing a task in order to eliminate or reduce ineffective movements and facilitates effective movements. By using motion study the task is redesigned to be more effective and less time consuming.
- The principles of motion study are grouped into three categories (a) use of the human body (b) arrangement of workplace (c) design of tools and equipments.
- Micro motion study is the technique of recording and analysing the timing of basic elements of an operation with the objective of achieving the best method of performing the operation. It is one of the most accurate techniques of work analysis used for work improvement. It makes use of motion pictures of different activities or movement with the help of a camera. When picture camera is utilized, the procedure is known as "micro motion study".
- The purpose of micro motion study is to know the nature and path of movements for obtaining the elements of an operation. It studies the relationship between the activities of the operator and machine thereby keeping permanent record of the most efficient way of performing a task for future reference.
- Simultaneous Motion Cycle Chart (SIMO Chart) is a recording technique for micro motion study. This chart is based in the film analysis, used to record simultaneously on a common time scale the Therbligsor a group of Therbligs performed by different parts of the body of one or more operators.
- Memo-Motion is a technical term describing a specialized branch of photography applied to work study, that if taking photographs at fixed intervals to record information about an operation or process. It is a comparatively recent innovation, being first applied in America during 1946.

6.10 SELF ASSESSMENT QUESTIONS

1. Throw light on Motion study. Discuss the principles of Motion Study.
2. Elucidate micro motion study. What are the various purpose of micro motion study?
3. Describe micro motion study charts and its application.
4. What is SIMO chart. List some of the SIMO chart symbols.
5. Explain memo motion study and its application.
6. List out the advantages and disadvantages of memo motion study.
7. How micro and memo motion study helps in achieving desired results in any organization.
8. Distinguish between micro and memo motion study.

6.11 SUGGESTED BOOKS / REFERENCES

1. Chary S. N., Production and Operations Management, Mc Graw Hill Education.
2. Mahajan M., Industrial Engineering and Production Management, Dhanpati Rai &Co.
3. Chunawalla.S.A., Production Operations and Management, Himalaya Publishing House.

UNIT-7 WORK MEASUREMENT

Unit structure

7.0 Unit Objectives
7.1 Introduction of Work Measurement
7.2 Objectives of Work Measurement
7.3 Elements of Work Measurement
7.4 Types of Elements
7.5 Benefits of Work Measurement
7.6 Techniques of Work Measurement
7.7 Time Study
7.8 Steps in making Time Study
7.9 Computation of Standard Time
7.10 Synthesis Method
7.11 Predetermined Motion Time System
7.12 Advantages
7.13 Disadvantages
7.14 Analytical Estimating
7.15 Work Sampling
7.16 Objectives
7.17 Summary
7.18 Self Assessment Questions
7.19 Suggested Books/ Reference

7.0 UNIT OBJECTIVES

This unit presents a holistic approach to work measurement, its importance, utility, merits and demerits. Various techniques of work measurement have been explained in detail to have a comprehensive understanding of the chapter.

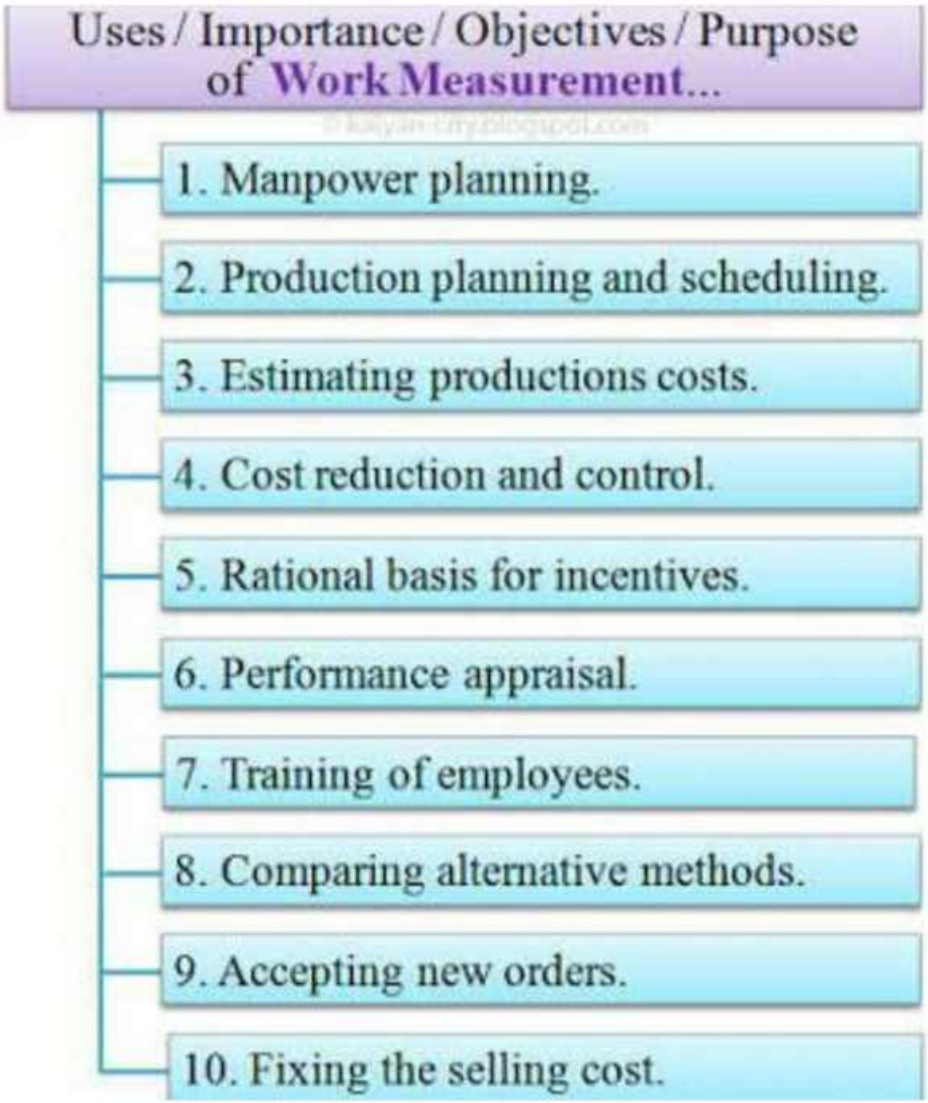
7.1 INTRODUCTION OF WORK MEASUREMENT

Work measurement is also called by the name 'time study'. Work measurement is absolutely essential for both the planning and control of operations. Without measurement data, we cannot determine the capacity

of facilities or it is not possible to quote delivery dates or costs. We are not in a position to determine the rate of production and also labour utilisation and efficiency. It may not be possible to introduce incentive schemes and standard costs for budget control.

Work measurement is mainly concerned with the determination of the total time required to perform a unit of work. It is defined as the application of techniques designed to establish the work content of a specified task, by determining the time required for carrying out the task at a defined standard of performance by a qualified worker. The amount of time required to complete a given job is expressed as time standard, work standard, labour standard, production standard or standard time. The standard time is the amount of time a qualified worker, working at a normal rate of speed, will require to perform the specified task. It is expressed in terms of minutes per unit or output per hour.

7.2 OBJECTIVES OF WORK MEASUREMENT



The use of work measurement as a basis for incentives is only a small part of its total application.

The objectives of work measurement are to provide a sound basis for:

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

7.3 ELEMENTS OF WORK MEASUREMENT

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

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

This division of jobs into elements is necessary to:

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

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

- Constant and variable time elements depending upon weight, size and so on
- Manual and machine elements
- Occasional or even foreign elements

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

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

7.4 TYPES OF ELEMENTS

- Repetitive: These elements occur in every cycle of the given task or activity, e.g., loading and unloading.
- Occasional: These elements do not occur in every cycle of the task, but may occur at random or at regular intervals, e.g., breaking of threads in textile unit.
- Constant: These elements may or may not occur in every cycle, but they are identified in specification and time from cycle to cycle. For example, switching on and off the machine, putting the cutting tool on the post and so forth.
- Variable: These are the elements where the time of performance varies with the characteristics of the products such as weight, size, etc., of the product. For example, loading and unloading of trunks.
- Manual: These are the elements performed by the worker.
- Machine: These are the elements which are automatically performed by machine, e.g. pressing, forging, etc.
- Governing: When two elements are present at the same time in a given cycle then that element which takes a longer time is called as

governing elements .For example, boiling the kettle water while setting out tea pot and cups.

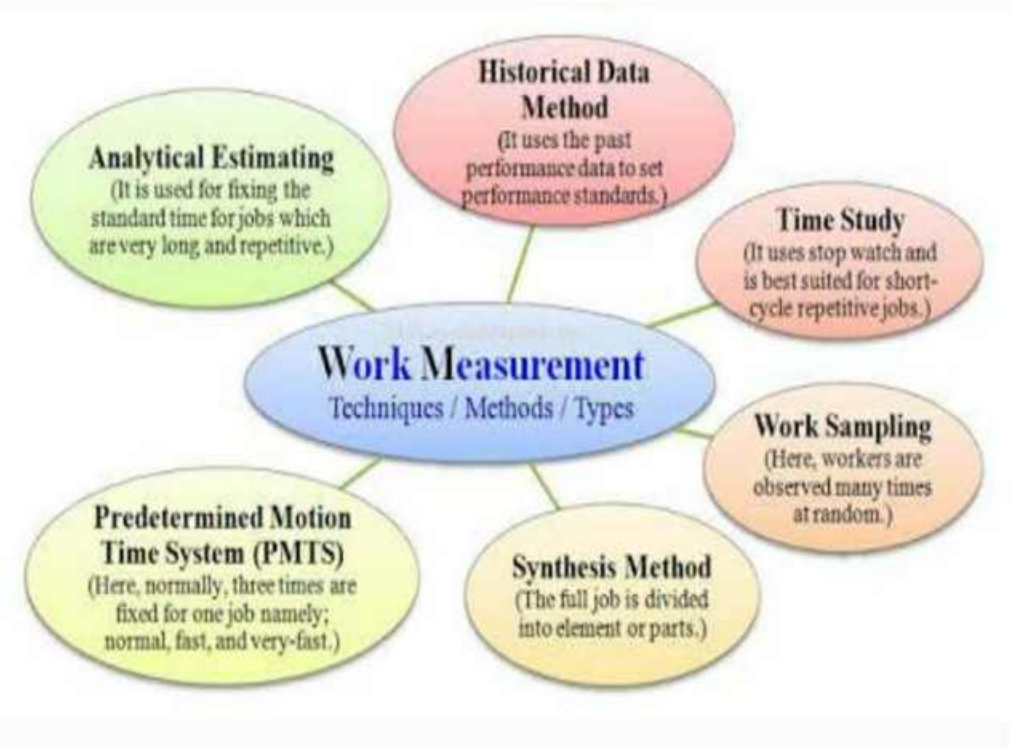
- Foreign: Those elements which are observed during the study but do not form the necessary part of the given activity of the cycle are known as foreign elements. For example, an operator stopping the machine when he wants to talk with his friend.

7.5 BENEFITS OF WORK MEASUREMENT

The work measurement technique is useful for:

- Developing a basis for comparing the alternative methods developed by the method study by establishing the work content in each method of doing the job.
- Correcting the manpower requirements for different tasks in a plant so that can be determined accurately by work measurement study.
- Preparing accurate work schedules by assessing human work.
- Planning and scheduling to meet delivery dates.
- Setting standards of performance for labour for each element of work under ideal conditions.
- Estimating production costs accurately.
- Comparing the time taken by the worker with the standard time to maintain effective control of labour.
- Accurately assessing the labour costs.
- Providing the basic information to take decisions relating to the selling price, and for a filling up the tenders.
- Developing new and more efficient methods.
- Providing a rational basis for evolving incentive schemes.
- Identifying the slow and standard workers for sending them for the training or treating them for their sickness.
- Training the new employees for specific elements of jobs.
- Checking progress of workers and taking necessary steps if required.

7.6 TECHNIQUES OF WORK MEASUREMENT



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

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

Various techniques of work measurement are:

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

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

1. **Time study :** A work measurement technique for recording the times and rates of working for the elements of a specified

job carried out under specified conditions and for analysing the data so as to determine the time necessary for carrying out the job at the defined level of performance. In other words measuring the time through stop watch is called time study.

2. **Synthetic data :** A work measurement technique for building up the time for a job or pans of the job at a defined level of performance by totalling element times obtained previously from time studies on other jobs containing the elements concerned or from synthetic data.

3. **Work sampling :** A technique in which a large number of observations are made over a period of time of one or group of machines, processes or workers. Each observation records what is happening at that instant and the percentage of observations recorded for a particular activity, or delay, is a measure of the percentage of time during which that activities delay occurs.

4. **Predetermined motion time study (PMTS) :** A work measurement technique whereby times established for basic human motions (classified according to the nature of the motion and conditions under which it is made) are used to build up the time for a job at the defined level of performance. The most commonly used PMTS is known as Methods Time Measurement (MTM).

5. **Analytical estimating :** A work measurement technique, being a development of estimating, whereby the time required to carry out elements of a job at a defined level of performance is estimated partly from knowledge and practical experience of the elements concerned and partly from synthetic data.

7.7 TIME STUDY

Time study is also called work measurement. It is essential for both planning and control of operations. Time study is defined as a technique for determining as accurately as possible, the time required to carry out a specified task by a qualified worker at a defined level of performance.

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

techniques designed to establish the time for a qualified worker to carry out a specified job at a defined level of performance."

The main objectives of time study are to:

- Provide the basis of comparing the operating effectiveness
- Establish labour standards for satisfactory performance
- Select the best method by comparing alternative methods
- Determine the standard costs equipments, labour and so on
- Determine normal times
- Provide the base for fixing piece rate or incentive wages
- Determine the cycle time for completion of a job

7.8 STEPS IN MAKING TIME STUDY

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

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

   Normal = Observed time * Rating / 100
7. Add the suitable allowances to compensate for fatigue, personal needs, and contingencies etc. to give standard time for each element.
8. Compute allowed time for the entire job by adding elemental standard times considering frequency of occurrence of each element.

9. **Make a detailed job description describing the method for which the standard time is established.**

10. **Test and review standards wherever necessary. The basic steps in time study are represented by a block diagram in the figure below :**

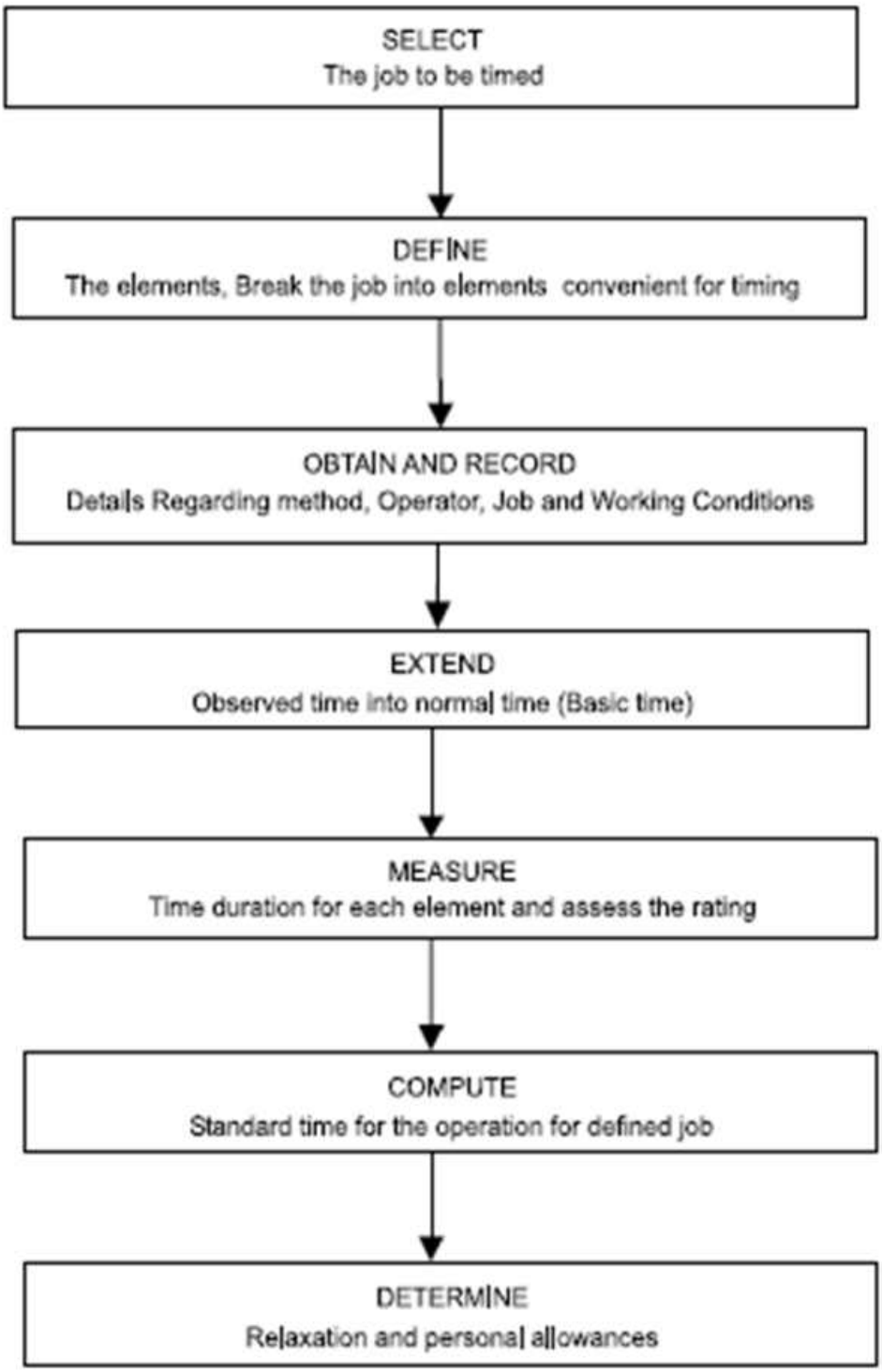


Fig: Steps in Time study

7.9 COMPUTATION OF STANDARD TIME

Standard time is the time allowed to an operator to carry out the specified task under specified conditions and defined level of performance. The various allowances are added to the normal time as applicable to get the standard time as shown in figure below:

Standard time may be defined as the, amount of time required to complete a unit of work:

(*a*) Under existing working conditions,

(*b*) Using the specified method and machinery,

(*c*) By an operator, able to the work in a proper manner, and

(*d*) At a standard pace.

Thus basic constituents of standard time are:

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

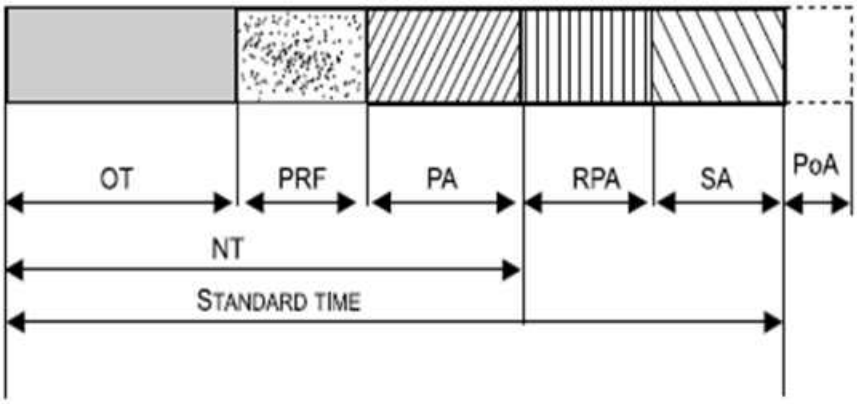


Fig : Components of Standard Time

OT – Observed Time

PRF – Performance Rating Factor

NT – Normal Time

PA – Process Allowances

RPA – Rest and Personal Allowances

SA – Special Allowances

PoA – Policy Allowances

Allowances

The normal time for an operation does not contain any allowances for the worker. It is impossible to work throughout the day even though the most practicable, effective method has been developed. Even under the best working method situation, the job will still demand the expenditure of human effort and some allowance must therefore be made for recovery from fatigue and for relaxation. Allowances must also be made to enable the worker to attend to his personal needs. The allowances are categorised as: (1) Relaxation allowance, (2) Interference allowance, and (3) Contingency allowance.

1. **Relaxation allowance**

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

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

   Fixed allowances constitute:

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

   (*b*) Allowances for basic fatigue: This allowance is given to compensate for energy expended during working. A common figure considered as allowance is 4% of the basic time.

2. **Variable allowance**

   Variable allowance is allowed to an operator who is working under poor environmental conditions that cannot be improved, added stress and strain in performing the job.

   The variable fatigue allowance is added to the fixed allowance to an operator who is engaged on medium and heavy work and working under abnormal conditions. The amount of variable fatigue allowance varies from organization to organization.

3. **Interference allowance**

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

The interference of the machine increases the work content.

Contingency allowance

A contingency allowance is a small allowance of time which may be included in a standard time to meet legitimate and expected items of work or delays. The precise measurement of which is uneconomical because of their infrequent or irregular occurrence. This allowance provides for small unavoidable delays as well as for occasional minor extra work. Some of the examples calling for contingency allowance are:

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

5. Policy allowance

Policy allowances are not the genuine part of the time study and should be used with utmost care and only in clearly defined circumstances. The usual reason for making the policy allowance is to line up standard times with requirements of wage agreement between employers and trade unions. The policy allowance is an increment, other than bonus increment, applied to a standard time (or to some constituent part of it, e.g., work content) to provide a satisfactory level of earnings for a specified level of performance under exceptional circumstances. Policy allowances are sometimes made as imperfect functioning of a division or part of a plant.

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

SOLUTION :

Obsessed time (or) selected time = 1.00 min

Rating = 120%

Allowance = 10%

As we know that, normal time = Observed time ×Rating % /100

$= 1.00 \times 120/100$

= 1.20 min

Allowance @ 10% $= 1.20 \times 10/100$

= 0.12 min

∴ Standard time = Normal time + Allowances

= 1.20 + 0.12 = **1.32 min.**

ILLUSTRATION 2 : An operator manufactures 50 jobs in 6 hours and 30 minutes.

If this time includes the time for setting his machine. Calculate the operator's efficiency.

Standard time allowed for the job was:

Setting time = 35 min

Production time per piece = 8 min

SOLUTION :

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

∴ Standard time for manufacturing 50 jobs

$= 35 + 8 \times 50$

= 435 min

= 7 hours and 15 min.

Efficiency of operator =Standard time × 100/Actual time

$= 435 \times 100/390$

= 111.5%.

7.10 THE SYNTHESIS METHOD

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

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

The standard data is a list of normal or basic values for different elements of jobs. It is prepared by including the timings of standard elements. As similar elements are present in several jobs there is no need to carryout time studies for then repeatedly. This is more economical to

use. Once the job elements are listed from the catalogue of standard data time the values for each element can be obtained and adding these values. We get estimate of normal times which can be converted into standard time by adding allowances.

Advantages :

- Helps in reducing cost of time studies.
- Time values are reliable as they are based on standard data.
- Can be used to estimate labour cost for new jobs

7.11 PREDETERMINED MOTION TIME SYSTEMS (PMTS)

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

Under this method:

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

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

7.12 ADVANTAGES

Predetermined Motion Time System (PMTS) possesses the following advantages :

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

7.13 DISADVANTAGES

Some of the disadvantages of Predetermined Motion Time System (PMTS) are as follows :

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

In spite of these limitations the PMTS is considered as the most ideal system to get accurate estimates, because, under it, careful analysis is carried out about all the motions involved to perform a given job.

7.14 ANALYTICAL ESTIMATING

This was developed in 1940's to study non-repetitive jobs. Under it, the elements are estimated and not timed. The time values are determined on the basis of the experience of the work study engineer when no synthetic or standard data are available. It calls for an experienced engineer having adequate knowledge about estimating motions study, time study and use of standard data.

The steps involved in this method of work measurement are:

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

(A) Advantages :

- Possesses all the advantages of the synthesis method.
- Helps in planning and scheduling production.
- Helps to fix the labour rate for non repetitive jobs
- Helps in improving labour control.

(B) Disadvantages :

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

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

7.15 WORK SAMPLING

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

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

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

For example: let out of 20 random observations, there are 5 idle observations. Then the percentage of idle time is 5/20 x 100 = 25%and percentage of working time will be 75%. If the shift is of eight hours then it may be concluded that the workers or machine remains idle for two hours and actually works for six hours only.

7.16 OBJECTIVES

Work sampling techniques' objectives are to:

- Estimate the non-working or idle time of an equipment machinery or employee.
- Estimate allowances for calculating standard times.

- Estimate the non-working or idle time of and equipment machinery or employee.
- Estimate the percentage of utilization of groups of similar machines.
- Provide basis for indirect labour time standards.
- Determine the standard time for a repetitive operation.

7.17 SUMMARY

- Work measurement is mainly concerned with the determination of the total time required to perform a unit of work.
- Work measurement is defined as the techniques applied to determine the amount of time required for a qualifies worker to perform a particular task.
- Main objective of work measurement is to fix the standard time for each job scientifically, which helps to workout realistic schedules and manpower requirements.
- The prominent techniques of work measurement are Time study, Synthesis method, Predetermined Motion Time System (PMTS).
- The PMTS technique is a technique of setting basic times for doing basic human activities necessary for carrying out a job so task.
- In analytical estimating, the time values are determined on the basis of the experience of the work study engineer when no synthetic or standard data are available.
- Synthesis is a technique of work measurement adopted to estimate the time required for doing a job at a defined level of performance by totalling the values of elemental times obtained form earlier time study on other jobs having similar job elements.

7.18 SELF ASSESSMENT QUESTIONS

1. Define work Measurement with a suitable example.
2. Explain the techniques of work Measurement. Also discuss its objectives.
3. Explain in detail the steps involved in making time study.
4. What is synthesis method. Why is it considered economical to use?
5. Discuss Predetermined Motion Time Study (PMTS) with the help of suitable example.
6. List out the advantages and disadvantages of Synthesis Method.

7. Explain the work sampling technique of work measurement. Also discuss its objectives.

8. Why companies provide allowances to their employees. What are its different kinds.

9. What is standard time? Discuss the components of standard time.

10. "Work Measurement is absolutely essential for both the planning and control operations." Justify this statement.

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Uttar Pradesh Rajarshi Tandon Open University

Master of Business Administration

MBA-3.34

Production, Planning and Control

BLOCK

3

PRODUCT PLANNING AND PROCESS PLANNING

UNIT-8

Product Planning

UNIT-9

Process Planning and Routing

UNIT-10

Quantity Determination in Batch Production

परिशिष्ट–4

आन्तरिक कवर–दो का प्ररूप

Format of the II Inner Covers

लेखक Dr. Ekta Verma, Asst. Professor MONIRBA University of Allahabad, Prayagraj

सम्पादक Prof. J.N. Bhargawa, MONIRBA, University of Allahabad, Prayagraj.

परिमापक

अनुवाद की स्थिति में

मूल लेखक	अनुवाद
मूल सम्पादक	भाषा सम्पादक
मूल परिमापक	परिमापक

सहयोगी टीम

संयोजक Dr. Gaurav Sankalp, SoMS, UPRTOU, Allahabd.

प्रूफ रीडर

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UNIT-8 PRODUCT PLANNING

Unit Structure

8.0 Unit Objectives

8.1. Product Planning

8.2. Objectives of Product planning

8.3. Components of product planning

8.4. Phases of product planning

8.5. Value analysis

8.6. Objectives of value Analysis

8.7. Types of values

8.8. Steps in value analysis

8.9. Summary

8.10. Self-assessment Questions

8.11. Suggested Books/ References

8.0. UNIT OBJECTIVES

This unit seeks to discuss and describe product planning, its importance, utility, merits and demerits. It also explains the concept of value analysis.

8.1. PRODUCT PLANNING

Product planning is the continuing process of identifying and accessing market demand and requirement that characterize a products feature set. Product planning serves as the basis for decision about promotion price and distribution. It is a process of developing a product tide and sticking on it until the product is completely developed and later introduced in the market. Additionally, a company must form an exit strategy for its product in case the product have not been able to generate demand and does not attract higher sales figure. Product planning necessitates the whole process of product development by using various marketing strategies including price changes and promotion, increased distribution channels and product extensions or improvements.

According to Karl.H.Tietji, Product planning signifies three important considerations:

- Expansion and introduction of new product
- The Refinement of existing lines and ,marketing strategies according to the changing consumer taste needs and preferences,
- Discontinuance and elimination of Marginal or unprofitable products.

8.2. OBJECTIVES OF PRODUCT PLANNING

The need, main functions or objectives of production planning are as follows:

Fig : Objectives of Production Planning

- To fulfil the customers need: Product planning identifies customers need,requirement, specifications, aspirations, liking and preferences and also guides the firm resources and efforts towards the accomplishment of them.
- To spotlight firms strength and weakness: each firm has its own strength and weakness .the future plans,the blueprint of actions is

founded in product planning on the set of the given strength and weakness. By pinpointing strength and weakness the product can be devised as to minimize the weakness and maximize its strength.

- To fortify better resource utilization: The minimum cost level of production is possible only when the company resources are geared to its production plan. As product planning is resulted with development of better quality products improvement of existing ones to changing customer taste and needs the limited and costly resources are so employed as to the greatest ,better, cheaper production.
- To guarantee T firm's survival: products are the hope for firm's survival. The product that fulfils the ever changing need of the consumers taste and needs enables the firm to survive successfully. Product renovation and innovation are the two set strategies which are considered to be quite important for those firms who want to survive for many years to come.
- To increase firm's sale: Every firm depends on sales as the only source of income to meet the outgoing and retain a decent margin to justify its hard work of putting resources and taking risks every firm wants to milk maximum sales by targeting right consumers class at the right time.

8.3. COMPONENTS OF PRODUCT PLANNING

The basic components of Product planning are as follows:

1. **Product innovation**: An innovation is the idea of producing new products or developing new processes, which is considered to be very useful. Innovation is radical to both growth and change .most marketing firms and industrial units will be unable to survive at the time off competitive environment,if they are unable to serve the innovative product .innovation generates demand and thus motivate firms to produce innovative and technically advanced products with an aim to serve the present and potential market at a profit .It means to translate ideas into products and products into profits.
2. **Product Diversification:** Product diversification implies to product expansion in depth and its width.
    - *Depth of product Line*: implies to assortment of colours, size, design, quality, and style etc.
    - *Width of product line*: implies to various number of product line.

    Diversification encourages growth and development as well as stability to an organization for a longer duration. It results

in creating higher profits .diversification acts as catalyst in the situation of financial crunch and managerial inefficiency.

3. **Product Standardization:** Standardization refers to the limitation of the numbers of varieties or types originating a given class. Large quantities of or a limited varieties of uniform quality may be manufactured by the manufacturer reducing unnecessary varieties. Standardisation helps in contributing towards economies of cost and human resources ,thus using the scarce resources very effectively and conserving the scarce inputs for the use of the future generations.

4. **Product eliminations:** As a part of business cycle , every company goes through a stage where some of its product are to be eliminated from its product line .Product elimination is not an easy task , which cannot be done overnight .if the things are taken lightly , it may affect the growth of the company and may demoralize the firm.

   The biggest problem of product elimination is psychological in nature; the marketer is reluctant to give up the product, because he has invested huge capital,time and efforts during different phases of business cycle.

   Another problem is from ethical point of view .the marketer has a fear ,as to when he has to inform the public about the elimination and whether he will be able to supply spare parts after shake service even after that.

   So product elimination should be done on financial analysis of the total history of the product. Product limitation restricts the misutilization of costly raw material in the form and helps in making better alternative investments.

5. **Product Customization:** customization is the new frontier in business competition for both the manufacturing and service industries. As its core is a tremendous increase in variety and customization without a corresponding increase in cost. As its limit, it is the mass production of individually customized goods and service .on the contrary, it provides economic value and strategic advantage. The notion of mass customization was described as "producing goods and services to meet customer's needs of the individual with near mass production efficiency".

8.4. PHASES OF PRODUCT PLANNING

Product planning is the process of creating a product concept and taking it through till the product is launched in the market, and thereafter concentrating on promotion and sustenance strategies. A number of start-ups/ SMEs invariably stumble in their product planning stage. A finished product is the result of long laborious hours of brainstorming, research,

analysis and planning, and if not given the due time and thought-process, can result in a complete failure of the business venture.

We take a look at the Phases of Product planning from a small business perspective:

A. Planning Phase

B. Action Phase

C. Control Phase

A. Planning Phase

Planning is an exercise of intelligent anticipation in order to establish how an objective canbe achieved or a need fulfilled in circumstances, which are invariably restrictive. Productionplanning determines the optimal schedule and sequence of operations economic batch quantity,machine assignment and dispatching priorities for sequencing.

It has two categories of planning namely:

1. Prior planning
2. Active planning

Prior planning

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

Modules of pre-planning

The modules of prior planning are as follows:

1. Product development and design is the process of developing a new product with allthe features, which are essential for effective use in the field, and designing it accordingly.At the design stage, one has to take several aspects of design like, design for selling,design for manufacturing and design for usage.
2. Forecasting is an estimate of demand, which will happen in future. Since, it is only anestimate based on the past demand, proper care must be taken while estimating it. Giventhe sales forecast, the factory capacity, the aggregate inventory levels and size of thework force, the manager must decide at what rate of production to operate the plant overan intermediate planning horizon.
3. Aggregate planning aims to find out a product wise planning over the intermediateplanning horizon.

4. Material requirement planning is a technique for determining the quantity and timingfor the acquisition of dependent items needed to satisfy the master production schedule.

Active Planning

Modules of active planning

The modules of active planning are as follows:

1. Process planning and routing is a complete determination of the specific technologicalprocess steps and their sequence to produce products at the desired quality, quantity andcost. It determines the method of manufacturing a product selects the tools and equipment,analyses how the manufacturing of the product will fit into the facilities. Routing inparticular prescribes the flow of work in the plant and it is related to the considerationsof layout, temporary locations for raw materials and components and materials handlingsystems.

2. A material planning is a process which determines the requirements of various rawmaterials/subassemblies by considering the trade-off between various cost componentslike, carrying cost, ordering cost, shortage cost, and so forth.

3. Tools' planning determines the requirements of various tools by taking process specification(surface finish, length of the job, overall depth of cut etc.), material specifications (typeof material used, hardness of the material, shape and size of the material etc.) and equipmentspecifications (speed range, feed range, depth of cut range etc.).

4. Loading is the process of assigning jobs to several machines such that there is a loadbalance among the machines. This is relatively a complex task, which can be managedwith the help of efficient heuristic procedures.

5. Scheduling is the time phase of loading and determines when and in what sequence thework will be carried out. This fixes the starting as well as the finishing time for each job.

B. Action Phase

Action phase has the major step of dispatching. Dispatching is the transition from planningphase to action phase. In this phase, the worker is ordered to start manufacturing the product.The tasks which are included in dispatching are job order, store issue order, tool order, time ticket,inspection order, move order etc.The job order number is the key item which is to be mentioned in all other reports/orders.Stores issue order gives instruction to stores to issue materials for manufacturing the productas per product specifications. As per tooling requirements for manufacturing the

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

C. Control Phase

The control phase has the following two major modules:

1. Progress reporting, and
2. Corrective action.

Progress reporting

In progress reporting, the data regarding what is happening with the job is collected. Also, ithelps to make comparison with the present level of performance. The various data pertaining tomaterials rejection, process variations, equipment failures, operator efficiency, operator absenteeism, tool life, etc., are collected and analysed for the purpose of progress reporting.These data are used for performing variance analysis, which would help us to identify critical areas that deserve immediate attention for corrective actions.

Corrective action

The tasks under corrective action primarily make provisions for an unexpected event. Someexamples of corrective actions are creating schedule flexibility, schedule modifications, capacitymodifications, make or buy decisions, expediting the work, pre-planning, and so on. Due tounforeseen reasons such as, machine breakdown, labour absenteeism, too much rejection dueto poor material quality etc., it may not be possible to realize the schedule as per the plan. Under such condition, it is better to reschedule the whole product mix so that we get a clear pictureof the situation to progress further. Under such situation, it is to be re-examined for selection appropriate course of action. Expediting means taking action if the progress reporting indicate deviations

from the originally set targets. Pre-planning of the whole affair becomes essential in case the expediting fails to bring the deviated plan to its right path.

8.5. VALUE ANALYSIS

Value Analysis aims at a systematic identification and elimination of unnecessary costs resulting in the increased use of alternatives, less expensive material, cheaper designs, less costly methods of manufacturing etc. to provide the same performance, quality and efficiency and in a decrease of overall unit costs and consequently greater profits. We can convert a stainless steel part into steel or even fibre-glass and thus save costs. TVS Suzuki's choice of fibre- glass for Spectra scooters has reduced its product-cost.

Value Analysis is, in essence, a study of function. The function of a part, or material, or service is the job it does. Value is the price we pay for a product process, material or service required to perform a specific function in an efficient way. We get the best value when we incur the least cost for an essential function or service with the required quality and reliability. The task of value Analysis is to ensure that all the elements of cost whether for labour, for material, for designing or for services, contributes proportionately to the function.

Value analysis is a cost reduction technique and perhaps the most potent of all such techniques. Cost reduction is a very dynamic concept unlike, for example, cost control. In cost control we are aiming to keep cost within predetermined standards while in "Cost Reduction" our objective is to attack themselves and eliminate them where possible. Value analysis parses a product into the functions performed by different components- and then looks for the cheapest way to have that function performed.

8.6. OBJECTIVES OF VALUE ANALYSIS

The main aim of value analysis is to generate promising ideas to

a. Simplicity of the product

b. Use (new) cheaper and better material

c. Modify and improve product design

d. Use efficient processes

e. Reduce product cost

f. Increase the utility of the product by economical means

g. Save money or to increase the profit.

8.7. TYPES OF VALUE

'Value' is a word that is very often used by individuals without being clearly understood. Forget about common people. Even different departments of the same organisation have different opinions of the 'value' of the product that the company manufactures. The designer equates value with reliability; purchase people with price paid for them; production personnel with that of cost from the angle of manufacture; sales people with what customer is willing to pay. In the field of value investigation, value refers to economic value, which itself can be sub-divided into four types as:

1. Cost value
2. Functional Value
3. Exchange value
4. Esteem value

Cost Value: This value is measured in terms of cost involved. In case of a manufacturing concern it refers to the cost of production of the product produced and if some part of the product is purchased from outside, it means cost of purchase of that part.

Functional value: Itrelates to the product's or the service's ability to perform its utilitarian purpose. Functional value can have several dimensions.One dimension would be performance related. This relates to characteristics that would have some degree of measurability, such as appropriate performance, speed of service, quality, or reliability. A car may be judged on its miles per gallon or the time to go from zero to sixty miles per hour. These concepts can also be seen when evaluating a garage that is performing auto repairs. Customers have an expectation that the repairs will be done correctly, that the car will not have to be brought back for additional work on the same problem, and that the repairs will be done in a reasonable amount of time. Another dimension of functional value might consider the extent to which the product or the service has the correct features or characteristics. In considering the purchase of a laptop computer, customers may compare different models on the basis of weight, battery lifetime, or speed. The notion of features or characteristics can be, at times, quite broad. Features might include aesthetics or an innovation component. Some restaurants will be judged on their ambiance; others may be judged on the creativity of their cuisine. Another dimension of functional value may be related to the final outcomes produced by a business. A hospital might be evaluated by its number of successes in carrying out a particular surgical procedure.

Exchange Value: Certain characteristics of a product facilitate its exchange for something else and what we get is the exchange

value of that product. It is equivalent to its sale value. All these values play an important part in our personal lives, but in value analysis, we are mainly concerned with use value and to some extent to the esteem value.

All other valued should be subordinated to use value in varying degrees. Value of a product manufactured for sale is the least amount spent in manufacturing it to create appropriate use and esteem values. Thus, value analysis seeks to provide the different values required in a product or service at the least cost without impairing its quality, efficiency and attractiveness.

Esteem Value: Certain properties of a product do not increase its utility or performance but they make it estimable which would induce customers to purchase the product. For example, a watch with gold cover has esteem value. A rich customer may prefer a watch with gold cover although a watch with a steel cover may serve the same purpose of keeping time.

Some products may have both uses as well as esteem value and yet both may be important. For example, a fountain pen with a gold plated body will have both use and esteem value as it will not only look better but will also last longer.

8.8. STEPS IN VALUE ANALYSIS

There are five stages involved in the value analysis of Materials. The stages are:

1. Information Stage
2. Functional Analysis
3. Brain Storming
4. Evaluation Phase
5. Implementation Phase.

Value Analysis of Materials: Stage # 1.

Information Stage:

Information regarding raw materials and the finished product — their cost, manufacturing method, performance characteristics etc.—are collected and studied.

Value Analysis of Materials: Stage # 2.

Functional Analysis:

The functions of the material are listed in terms of basic functions and secondary functions. The listed functions are given value points or the

weightages in term of its importance or disability. The cost incurred for each of the functions is also mentioned.

When the cost and the value points are placed side by side, it immediately reveals where much money is spent for little value. Say, the value of a function is small; the function can be dropped altogether in the substitute products.

Value Analysis of Materials: Stage # 3.

Brain Storming:

This third step in the value analysis starts with the thinking of various alternative possibilities for the material. At this stage, activities encouraged. Many suggestions at this stage are recorded though not accepted. This is the break away from rigid thinking and encouragement of creativity. *"Some system of brain-storming start idea generation from such widely differing 'triggers' as politics and geography and develop them further so as to apply to the problem at hand—S N Chary".*

Value Analysis of Materials: Stage # 4.

Evaluation Phase:

Ideas generated are evaluated. This evaluation is done by finding the various functions that the substitute can perform for each of those functions at what cost and to what extent. This evaluation will indicate a few of the alternatives, whose functional value may compare with that of the earlier material but a reduced cost. The evaluation may reveal some substitutes having enhanced important functional values.

Value Analysis of Materials: Stage # 5.

Implementation:

Implement-ability of the selected substitutes or new ideas is discussed with the appropriate departments. Seeming of substitutes/ ideas is done and only a limited few is put to implementation. Next comes programme planning phase where the programme for studying the various alternatives in greater depth is laid down.

In the execution process next, all the alternatives with the costs and benefits, are studied according to the programme/plan to arrive at the best alternative. Last phase deals with the presentation and implementation. All relevant data are presented to the authority for decision. The accepted ideas are then implemented and the actual benefits are studied.

8.9. SUMMARY

- Product planning signifies three important considerations:
  - (a) Expansion and introduction of new product.

(b) The Refinement of existing lines and,marketing strategies according to the changing consumer taste needs and preferences.

(c) Discontinuance and elimination of Marginal or unprofitable products.

- Product Planning focuses on product innovation, product diversification, product diversification, product elimination and product customization.
- Tools' planning determines the requirements of various tools by taking process specification(surface finish, length of the job, overall depth of cut etc.), material specifications (typeof material used, hardness of the material, shape and size of the material etc.) and equipmentspecifications (speed range, feed range, depth of cut range etc.).
- In progress reporting, the data regarding what is happening with the job is collected. Also, ithelps to make comparison with the present level of performance. The various data pertaining tomaterials rejection, process variations, equipment failures, operator efficiency, operator absenteeism, tool life, etc., are collected and analysed for the purpose of progress reporting.
- Expediting means taking action if the progress reporting indicate deviations from the originally set targets. Pre-planning of the whole affair becomes essential in case the expediting fails to bring the deviated plan to its right path.
- *"Cost Value"* is the measure of sum of all costs incurred in producing the product. The'cost value', therefore is the sum of raw-material cost, labour cost, tool cost andoverheads expended to produce the product.
- *"Exchange Value"* is the measure of all the properties, qualities and features of theproduct which make the product possible of being traded for another product or formoney.
- *"Use Value"* is the measure of properties, qualities and features which make theproduct accomplish a use, work or service. Use value, therefore, is the price paid by thebuyer or the cost incurred by the manufacturer in order to ensure that the productperforms its intended function efficiently.
- "Esteem Value" is the measure ofproperties, features, attractiveness graphic packaging and the like which increases salesappeal or which attracts customers and create in them a strong desire to own theproduct.

8.10. SELF-ASSESSMENT QUESTIONS

Q1. What is Production Planning? Why it is important for the industry.

Q2. What is the purpose of product planning?

Q3. What are the components of Product planning? How are they interrelated to each other?

Q4. A control system should be stable and efficient. Elaborate this statement in the light of control phase suggested in this chapter.

Q5. What is Value Analysis? Explain its various types and steps involved in value analysis.

8.11. SUGGESTED BOOKS/ REFERENCES

1. Chary S.N.: Production and Operations Management, McGraw Hill Education
2. Mahajan M.: Industrial Engineering and Production Management, DhanpatRai& Co.
3. Chunawalla S.A., Patel D.R.: Production and Operation Management, Himalaya publishing House

UNIT-9 PROCESS PLANNING AND ROUTING

Unit Structure

9.0. Unit Objectives

9.1. Process planning

9.2. Process planning process

9.3. Process capabilities

9.4. Conceptions of process characterization

9.5. Routing

9.6. Techniques of routing

9.7. Summary

9.8. Self-Assessment Questions

9.9. Suggested Books/ References

9.0. UNIT OBJECTIVES

This unit aims to explain process planning and routing, its importance, utility, merits and demerits. It also highlights the pre requisite information needed for process planning.

9.1. PROCESS PLANNING

Process planning for manufacturing covers a wide range of activities needed to specify the manufacturing process for a part. Unfortunately, the process planning terminology "is somewhat fuzzy" and there is no commonly adopted or standardised definition of what is included or not, nor for the activities whatever they may be. "Process planning is defined as the activity of deciding which manufacturing processes and machines should be used to perform the various operations necessary to produce a component, and the sequence that the processes should follow."

A more comprehensive definition of the aim of process planning for manufacturing is that:

"Process planning, in the manufacturing context, is the determination of processes and resources needed for completing any of the manufacturing processes required for converting raw materials into a final

product to satisfy the design requirements and intent and respect the geometric and technological constraints."

An important addition to these constraints is that the manufacturing must be cost-effective for a business to be successful. This is realised by a well-running manufacturing process in addition to efficient process planning to meet agreed deadlines. Process planning is also described to be the interface between product design and manufacturing, and the work often includes coordination of product design intentions and constraints imposed by the workshop. The process planner therefore plays a desirable role not only to define a process plan but to contribute withmanufacturing knowledge to a competitive product design. To bring some clarity in different focuses for process planning, four process planning levelshave been defined according to Table 1. These levels are placed in order from a very low level of detail to a very detailed level. In addition, the focus and output from each level are identified.

Process planning level	**Main focus of planning at this level**	**Level of detail**	**Planning output at this level**
Generic planning	Selecting technology and rapid process planning	Very low	Manufacturing technologies and processes, conceptual plans, and DFx analysis results
Macro planning	Multi-domain	Low	Routings, nonlinear plans, alternate resources
Detailed planning	Single domain, single process	Detailed	Detailed process plans (sequence, tools, resources, fixtures, etc.)
Micro planning	Optimal conditions and machine instructions	Very detailed	Process/Operation parameters, time, cost, etc., NC codes

Table 9.1 : Process planning levels

This definition of process planning levels is established in the academic research community but is not so well known by process planners in industry. The probable reason is that in practice these four levels overlap each other and are difficult to distinguish. More easily recognized are the main activities related to process planning. These activities have been listed in ten steps:

1. Interpretation of product design data (CAD data, material properties, batch size, tolerances, surface definition, heat treatment and hardness, special requirements).
2. Selection of machining processes (e.g. turning milling, drilling and grinding), usually based on a company specific strategy.
3. Selection of machine tools considering for example availability, process capability, machining range and production rate.
4. Determination of fixtures and datum surfaces.
5. Sequencing the operations.
6. Selection of inspection devices.
7. Determination of production tolerances.
8. Determination of the proper cutting tools and conditions (e.g. depth of cut, feed rate and cutting speed).
9. Calculation of the overall times (machining, non-machining and set-up times).
10. Generation of process sheets, operation sheets and NC data.

There is no established definition of what a process plan is, and what process planning work shall include, furthermore not all process planners in all companies may perform all of the activities. Process planning has been, and still is, mainly a knowledge intensive manual task performed by a skilled person because of its multi-perspective problem nature including "problem-solving, constraint-reasoning, goal-achieving, resource utilisation and conflict-resolution". Although computer aided process planning (CAPP) has been on the production research agenda for decades it has not been commonly assimilated into industry. In the end, the goal for the process planner is to design a manufacturing process that is capable of producing a part that fulfils all design requirements, without incurring high economic costs. It emphasises on the major impact that process planning has on factory activities and the resulting manufacturing costs. Process planning is, and will be, an important issue for all manufacturing companies, no matter whether manual, computer-aided or, most probably, a combination.

9.2. PPP - THE PROCESS PLANNING PROCESS

To clarify the general conception of process planning it is appropriate to make some more statements and explain the desired goal for the process planner.

Process planning is work that includes all needed activities to define a process plan. A *process plan* is a specification that contains information aimed to facilitate production of a certain part in a definite manufacturing system. In practice, two tacit boundary conditions narrow this definition; the process plan must be defined in a way that ensures that the produced part fulfils all requirements stated in the design specification as well as minimising the production cost.

As process planning in general is a very broad topic it is here delimited to fit the purpose of this thesis. My approach to giving an overview of the process planning domain is shown in figure as a flow chart of the "process planning process" (PPP). The PPP flow chart includes activities derived from my own experiences and ideas; many of them, especially sub-activities, are also found among the ten activities.

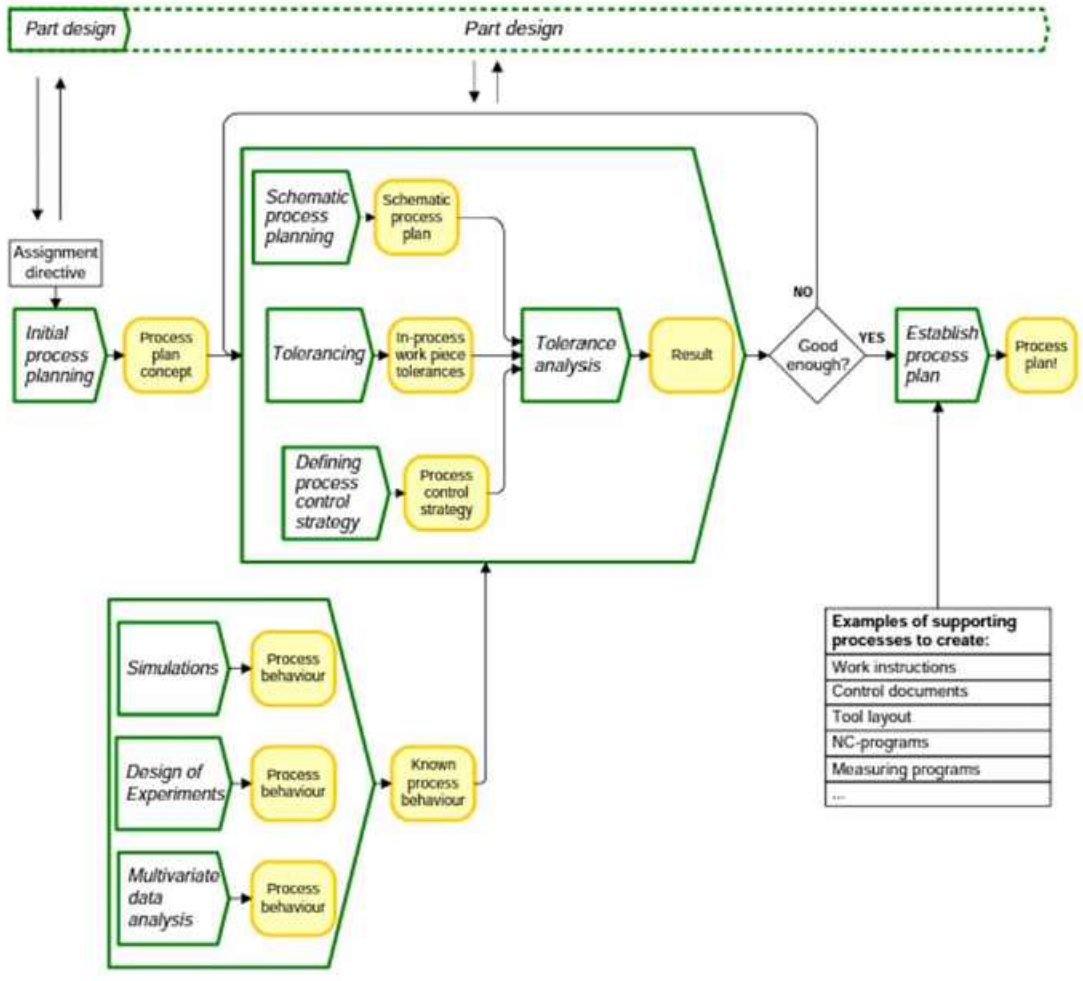

Figure 9.2 : The PPP flow chart – an approach to describe the process planning process (PPP).

According to Figure, the main flow starts with the activity "*initial process planning*" on receiving an assignment directive. The result is a process

plan concept where the main directions of the following work have been set. This is used together with knowledge about the behaviour of relevant manufacturing processes as input to the three following process planning activities.

These three activities are interdependent and are performed in an iterative way starting with *schematic process planning*. Schematic process planning includes, for example, interpretation of design requirements, definition of production and operation sequence, machine tools, cutting and work holding tools.

Tolerancing is to define In-Process Workpiece (IPW) tolerances in conjunction with the schematic process plan, process behaviour and design specification of the part.

The *process control strategy* is based on both the schematic process plan and the required tolerances, but also on the behaviour of all included processes.

The defined process plan is then analyzed regarding tolerances and the expected outcome of the process. The results are tested against acceptance criteria to decide whether the defined manufacturing process can be approved or not. If the manufacturing process has all the necessary qualities to succeed, the process plan can be established and all needed documents, programs, working instructions, etc. created.

9.3. PROCESS CAPABILITY – A BOUNDARY CONDITION FOR PROCESS PLANNING

Because a manufacturing process that produces virtually no products out of specification tends to be very expensive, there is often an acceptance criterion allowing a small amount of deviation from specification. This criterion is commonly defined as the lowest acceptable level of a Process Capability Index (PCI), the highest number of defect Parts Per Million (PPM) or sometimes as maximum Defects Per Million Opportunities (DPMO). The aim of using this kind of criteria is to prohibit poor production process performance in relation to the requirement, preventing adherent high quality deficiency costs.

PCIs is often used to set a limit for the lowest acceptable process capability, but has not been used for limiting the highest acceptable process capability. The aim of a higher limit should be to prevent excessive manufacturing cost due to overqualified manufacturing resources; this is in contrast to the commonly used lower limit which aims to save the customer from getting a product out of specification. Even though a useful higher limit of capability index is not defined in the literature, the assumption here is that the process planner must try to obtain a balance between required product performance and the economic efforts put into the manufacturing process.

9.4. CONCEPTIONS OF PROCESS CHARACTERISATION

Until now, three conceptions of a similar kind have been used to characterise a process; process performance, process behaviour and process capability. Some clarifications are in order to avoid confusions.

- "Process performance" refers to the accuracy of the process when creating a final part dimension or an IPW dimension.
- "Process behaviour" is a representation of the manner, or action, of the manufacturing process.
- "Process capability" is dedicated to the established conception of PCI where a tolerance range is related to a statistical representation of the process behaviour.

9.5. ROUTING

Routing may be defined as the selection of path which each part of the product will follow while being transformed from raw materials to finished products. Path of the product will also give sequence of operation to be adopted while being manufactured. In other way, routing means determination of most advantageous path to be followed from department to department and machine to machine till raw material gets its final shape, which involves the following steps:

(*a*) Type of work to be done on product or its parts.

(*b*) Operation required to do the work.

(*c*) Sequence of operation required.

(*d*) Where the work will be done.

(*e*) A proper classification about the personnel required and the machine for doing the work.

For effective production control of a well-managed industry with standard conditions, the routing plays an important role, *i.e.*, to have the best results obtained from available plant capacity. Thus routing provides the basis for scheduling, dispatching and follow-up.

9.6. TECHNIQUES OF ROUTING

While converting raw material into required goods different operations are to be performed and the selection of a particular path of operations for each piece is termed as 'Routing'. This selection of a particular path, *i.e.* sequence of operations must be the best and cheapest to have the lowest cost of the final product. The various routing techniques are:

1. **Route card :** This card always accompanies with the job throughout all operations. This indicates the material used during manufacturing and their progress from one operation to another. In addition to this the details of scrap and good work produced are also recorded.

2. **Work sheet :** It contains

   (*a*) Specifications to be followed while manufacturing.

   (*b*) Instructions regarding routing of every part with identification number of machines and work place of operation.

   This sheet is made for manufacturing as well as for maintenance.

3. **Route sheet:** It deals with specific production order, generally made from operation sheets. One sheet is required for each part or component of the order. These include the following:

   (*a*) Number and other identification of order.

   (*b*) Symbol and identification of part.

   (*c*) Number of pieces to be made.

   (*d*) Number of pieces in each lot—if put through in lots.

   (*e*) Operation data which includes:

      (*i*) List of operation on the part.

      (*ii*) Department in which operations are to be performed.

      (*iii*) Machine to be used for each operation.

      (*iv*) Fixed sequence of operation, if any.

   (*f*) Rate at which job must be completed, determined from the operation sheet.

4. **Move order :** Though this is document needed for production control, it is never used for routing system. Move order is prepared for each operation as per operation sheet. On this the quantity passed forward, scrapped and to be rectified are recorded. It is returned to planning office when the operation is completed.

9.7. SUMMARY

- Process planning, in the manufacturing context, is the determination of processes and resources needed for completing any of the manufacturing processes required for converting raw materials into a final product to satisfy the design requirements and intent and respect the geometric and technological constraints.

- Process planning has been, and still is, mainly a knowledge intensive manual task performed by a skilled person because of its multi-perspective problem nature including problem-solving, constraint-reasoning, goal-achieving, resource utilization and conflict-resolution.
- The *process control strategy* is based on both the schematic process plan and the required tolerances, but also on the behaviour of all included processes.
- Routing may be defined as the selection of path which each part of the product will follow while being transformed from raw materials to finished products. Path of the product will also give sequence of operation to be adopted while being manufactured
- Route sheet deals with specific production order, generally made from operation sheets. One sheet is required for each part or component of the order.

9.8. SELF- ASSESSMENT QUESTIONS

Q1. Define Process Planning. Enumerate the process planning levels in light of this chapter.

Q2. List out the main activities related to process planning.

Q3. Explain in detail the working of process planning.

Q4. What is routing? List out the steps involved in routing.

Q5. Conversion of raw materials into finished goods requires sequence of operations. Explain.

9.9. SUGGESTED BOOKS/ REFERENCES

1. Chary S.N.: Production and Operations Management, McGraw Hill Education
2. Mahajan M.: Industrial Engineering and Production Management, DhanpatRai& Co.

UNIT-10 QUANTITY DETERMINATION IN BATCH PRODUCTION

Unit Structure

10.0. Unit Objectives

10.1. Batch production

10.2. Batch Size

10.3. Line of Balance for control of batch production

10.4. Aggregate production Planning

10.5. Material Requirement planning

10.6. Summary

10.7. Self-Assessment questions

10.8. Suggested Books/ References

10.0. UNIT OBJECTIVES

This unit provides a comprehensive understanding of quantity determination in batch production. An integrated process capability in a multi-product system has also been explained.

10.1. BATCH PRODUCTION

Batch production is done when a product is made in different varieties and the volume is less. This system works well for smaller facilities. The product is produced in smaller quantities but in different variants. The facility layout is designed keeping in mind the volume, flow and variety of the product. In batch production there is continuous demand for the product. The goal of calculating the optimal batch quantity of a product is that the product is produced in the required quantity and required quality at the lowest cost.

There are basically two options of planning the batch quantity:

- planning a large batch of a product in long intervals,
- planning a small batch of a product in short intervals.

The advantages of planning a large batch of product are:

- Price advantage of ordering a large batch (low cost, protection against raising prices, volume rebate),
- Lower administrative costs,
- Lower costs of tests and shipping,
- Low risk of interruption of production because of the large stock.

The disadvantages of planning a large batch of product are:

- High tied-up capital,
- High storage costs of product inventory.

The advantages of planning a small batch of product are:

- Low tied-up capital,
- Low storage costs of product inventory,
- High flexibility if quantities change at suppliers and buyers.

The disadvantages of planning a small batch of product are:

- The costs of frequent ordering,
- High risk of interruption of production because of a small product inventory.

Somewhere between the large and small batch quantity is the optimal batch quantity, i.e. the quantity in which the cost per product unit is the lowest.

10.2. BATCH SIZE

The lot size or batch size is decided based on the economic factor. It means that the best size of the batch is decided to keep the total cost to a minimum while keeping up with the demand. The production is such that all the variants of the product are sold simultaneously. The inventory of finished goods does not rise to its maximum point but builds up slowly as goods are produced faster than they are sold. Batch size depends on the following cost factors:

1. ***Set up cost*** : It consists of engineering cost of setting up of the equipment, paperwork cost of processing order and the cost of order placed for the raw materials.
2. ***Carrying Cost*** : These are incurred on the finished product from the time it is manufactured until it is finally sold.

Determination of batch sizes:

Too large a batch quantity would tie up a large capital in inventory. High inventory will also lead to high carrying or holding costs. Too small quantities would be inadequate to meet large fluctuations in demand and

the frequent processing of small batches. The batch quantity should, therefore, be optimum to minimise the total costs. We shall consider the model where the rate of processing and consumption are known and constant.

Consider the following the notations

Nu = Optimum process batch quantity

S = set up cost per batch

C = carrying cost per item per unit of time

r = consumption rate per unit of time

P = processing rate per unit of time

Then

$$\text{Average stock level} = Nu/2$$

$$\text{Optimum batch size} = Nu^* = \sqrt{\frac{2Sr}{C}}$$

$$\text{Total cost/unit of time} = C$$

$$\therefore C^* = \sqrt{2rSC}$$

$$\text{Processing cycle time, } t = \frac{Nu}{r}$$

$$\therefore t^* = \frac{Nu^*}{r}$$

$$Nu^* = \sqrt{\frac{2rS}{C_1}} \qquad \sqrt{\frac{C_1 + C_2}{C_2}}$$

$$C^* = \sqrt{2rC_1S} \qquad \sqrt{\frac{C_1}{C_1 + C_2}}$$

$$t^* = \frac{Nu^*}{r}$$

Let us consider the situation where the total processing batch is not delivered into stock at the same time. Instead, the items constituting the batch are delivered into the stock continuously throughout the process period.

$$\text{Average inventory} = \text{Buffer stock (B)} + \frac{Nu}{2}\ (1 - r/p)$$

$$Nu^* = \sqrt{\frac{2Cr}{C(P - r/P)}}$$

$$C^* = \sqrt{2rSC_1}\ \sqrt{1 - (r - P)}$$

$$t^* = \frac{Nu^*}{r}$$

Production Range (Processing Range)

It is difficult to establish accurately C1 and S. the total cost curve is therefore flat at minimum cost point. It means the total variable cost is not very sensitive to the Nu.it is possible to adopt a batch size that differs a bit from the optimal without affecting the costs. This gives rise to 'production range' concept. The quantities within this range are acceptable.

Economic Lot Size (or Batch Size)

We shall consider this with respect to **a** single product, and **b** multi-product case.

First let us get acquainted with three categories of costs in production function.

Set Up Cost

Batch production involves a set up cost, each time a batch is produced. Set up cost is roughly equivalent to the ordering cost per order. It consists of engineering cost of setting up the production lines or machines, paperwork cost of processing work order and authorizing production and ordering cost to provide raw materials for the batch or order.

Carrying Costs

These are incurred on the finished product from the time it is manufactured until it is finally sold.

Single Product: Optimum Lot Size

Let us be familiar with the symbols.

Production Runs

(OptimumNo. Year)

A = Annual Sales of Items in rupees

C = Carrying Costs as a per cent of finished goods.

S = Set up Cost per run

Nr = Optimum No. of runs per year.

Assumption

1) End Products are to be placed in stock
2) They are sold at a constant rate until some low level is reached.
3) At the level, another batch is produced.

Illustration

A company produces ₹ 40,000 worth of worm-gears at the factory each year. The carrying costs on finished stocks are 20 per cent per year and the set up costs per production runs is ₹ 80. Optimum number of production runs per year (N_r) for this item would be:

$$N_r = \sqrt{\frac{AC}{2S}} = \sqrt{\frac{₹\ 40{,}000(0.20)}{2(₹\ 80)}}$$

$$= \sqrt{\frac{₹\ 8{,}000}{₹\ 160}} = \sqrt{50} = \text{About 7 runs/year.}$$

The so-called *economic batch quantity* represents an attempt to calculate the best compromise on batch size, which also keeps the total costs to the minimum.

Production Lot Size: Simultaneous Production and sales

Here the end products being produced are simultaneously being sold. In the case, the inventory of finished goods does not generate immediately to its maximum point. Instead, its builds up slowly as goods are produced faster than they are being sold, then it declines to its lowest point as production of a particular batch ceases although sales continue. The concept is illustrated in the following figure.

$$Nu = \frac{\text{Optimum Production Run size (Units)}}{\text{Maximum finished Goods inventory (Production stops)}}$$

The inventory formula for optimum number of units (Nu) under these conditions is:

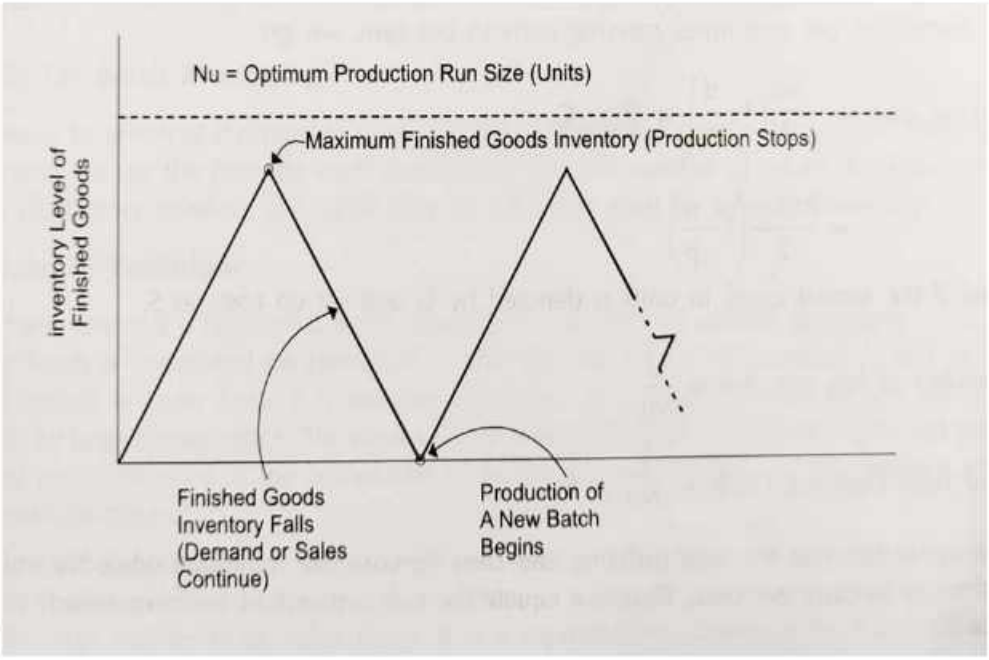

Fig : Simultaneous Production and Sales

$$Nu = \sqrt{\frac{2US}{RC\,(1 - d/p)}}$$

where,

Nu = Production runs equation (Optimum units per batch)

U = Annual Sales in units

S = Set up cost per batch

R = Factory cost per unit

C = Carrying costs as a per cent of finished goods

d = Sales rate (demand rate) in units per day

P = Production rate in units per day.

We can put down total ordering and carrying costs as follows:

Nu = Optimum lot size in units

and

P = Production rate in units daily

then

$\frac{Nu}{P}$ = No. of days required to receive entire order

If

d = Use rate in units daily

then

$\frac{Nu}{P} \times d$ = Number of units used during receipt period

$(Nu)\frac{-Nu}{P} \times d$ = Maximum inventory which can be build up

Since, average inventory is approximately half the maximum inventory, the average inventory in this case would be

$$\frac{1}{2}\left(Nu\frac{-Nu}{P} \times d\right) = \frac{1}{2}\,Nu\left(1 - \frac{d}{p}\right)$$

Let R represent Cost Per Unit and C represent Carrying costs. If carrying costs equal average inventory in units times cost per times carrying costs in per cent, we get

$$\text{Carrying costs} = \frac{Nu}{2}\left(1-\frac{d}{p}\right) \times R \times C$$

$$= \frac{RCNu}{2}\left(1-\frac{d}{p}\right)$$

And if the annual usage in units is denoted by U and set up costs as S.

$$\text{Number of lots per year} = \frac{U}{Nu}$$

$$\text{and Total Ordering Costs} = \frac{U}{Nu} \times S$$

We appreciate that the total ordering and carrying cost are minimum when the cost to order equals the cost to carry per year. Thus, we equate the two expressions we have already defined and solve for N :

$$\frac{US}{Nu} = \frac{RCNu}{2}\left(1-\frac{d}{p}\right)$$

$$RCNu^2 = \left(1-\frac{d}{p}\right) 2US$$

$$Nu^2 = \frac{2US}{RC\,(1-d/p)}$$

$$Nu = \sqrt{\frac{2US}{RC\,(1-d/p)}}$$

Multi- Product Case

Supposing several items (n) are made on a single machine, with a common CT (cycle time), then these batches (n) are phased within the common cycle. Here the total cost per year is the summation of the individual costs. For resource feasibility check, the equation for time becomes

$$\frac{d_1}{P_1} + \frac{d_2}{P_2} + \ldots + \frac{d_n}{P_n} \leq 1$$

It can be determined whether all items (n) can be scheduled on a single machine. The optimum cycle time (CT) can be obtained by putting

$$\frac{d \times \text{TotalAnnualCost} \times CT}{d \times CT} = 0$$

CT, therefore, becomes $\dfrac{\sqrt{2\sum_{j=1}^{n} \text{set up cost}}}{i\sum_{j=1}^{n} \text{variable cost per unit} \times d_i\left(1 - \frac{d_j}{P_j}\right)}$

Once CT is obtained the Optimum batch sizes Nu_1, Nu_2, Nu_3 can be easily obtained by using $Nu_j = CT\ d_j$, $j = 1 \ldots n$.

Scheduling For Batch Processing

We have to arrive at the most economical cycle that optimises the set up and carrying costs. As set up costs go up, the carrying costs goes down, and the number of cycles increases. However, to get the satisfactory solution, the cycle time for all items must be set simultaneously.

10.3. LINE OF BALANCE TECHNIQUE

We have assumed a sequential batch processing consisting of several operations (1,2,3 etc.) The whole batch is completed on operation 1, and then passes on to operation 2, and so on. The operations control is easier here. It is iterative. However, the throughout time for any batch will be high. It calls for large storage space. The ideal solution would be to divide the batches, to start processing on the next operation prior to the completion of processing of the batch on the previous one. Still, we must exercise control.

The line of balance technique takes care of such situation. It follows the principle of management by exception', it considers only the crucial operations in a job. It establishes a schedule for these. It is useful for large batches of complex items. It is a sophisticated version of the Gantt Chart.

Line of Balance (LoB) for control of Batch Production

LoB is useful when batches are split to study the progress of jobs periodically, and with reference to the delivery schedule, and construct an operations programme. While reviewing a programme progress chart is drawn. This chart shows the number of items which have been finished at each of the critical or important operations at a given date. Above this

chart is drawn a line (LoB) which shows the requisite number of items which should have been completed at each operation at the review time. Analysis of progress is then done. Shortage and non-conformance to schedule are identified. LoB is management by exception.

Batch Scheduling

There are basically three batching methods:

(i) Individual batch size fixed for each part.

(ii) Aggregation of parts which are treated as one batch.

(iii) Fixed batch quantity for a product rather than of parts.

Irrespective of the batching method used, we have to decide the order of processing the batches at the various stages of production. Suppose a certain machine has to take four batches for processing. It means this can be done in twenty-four ways. The more the number of batches the greater the ways of ordering the batches, e.g., eight batches gives over forty thousand ways. It is difficult to choose the particular scheduling sequence. We have to keep in mind the objectives of a schedule and its significance. Are we aiming to reduce the idle machine time or work-in-progress (WIP) or production costs? These may be desirable objectives, but in practice, they come in conflict. In a particular situation, we have to make a assessment of their relative costs. The problems should be kept simple by scrutinizing the product range and parts made for which a simple manufacturing process can be designed. Jobs which are troublesome are contracted out. Scheduling problems are eased by excess capacity. However, loading a plant fully increases the scheduling problems.

Problems and Prospects of Batch Production

Here, WIP and the lead times are large. Requirement planning is a tool to overcome this. MRP, however, needs computerization. Kanban system of japan emphasises the reduction in production lead time and WIP by using shorter production runs of a particular product.

FMS: Flexible Manufacturing system is a tool to overcome problems of batch production. FMS machines through general purpose are versatile enough to perform different operations which are linked by material handling system. The machine and material handling are controlled by a computer system. FMS makes possible machining of desired mix of parts in a given time period. It reduces WIP and increases machine utilisation in small batch manufacturing.

10.4. AGGREGATE PRODUCTION PLANNING

Demand from consumers is met by keeping up the production levels. The plan for the next few months is scheduled. The work force and the machine allocation time is developed. Such an aggregation creates an overall production plan for all the variants of the product. For e.g.; ice

cream factory. Individual product schedule are obtained by breaking up the overall production plan for flavours like chocolate, vanilla, mango etc.

Demand from customers gets converted as units of product while considering the production system. The plan of the next few coming months has a demand schedule. It is to be met by developing the workforce and the machine time allocation which is called aggregate production planning. Aggregation results an overall production plan for all the products (e.g., tonnes of soap). Individual product schedules, for example of toilet premium soaps, janta soaps, washing soaps are obtained by breaking up the overall plan (disaggregation).

While allocating workforce, there are two conflicting considerations. The inventory carrying cost is to be balanced against the cost of adjusting activity levels to variations in demand. The demand pattern of two alternative production strategies is seen in the following diagram.

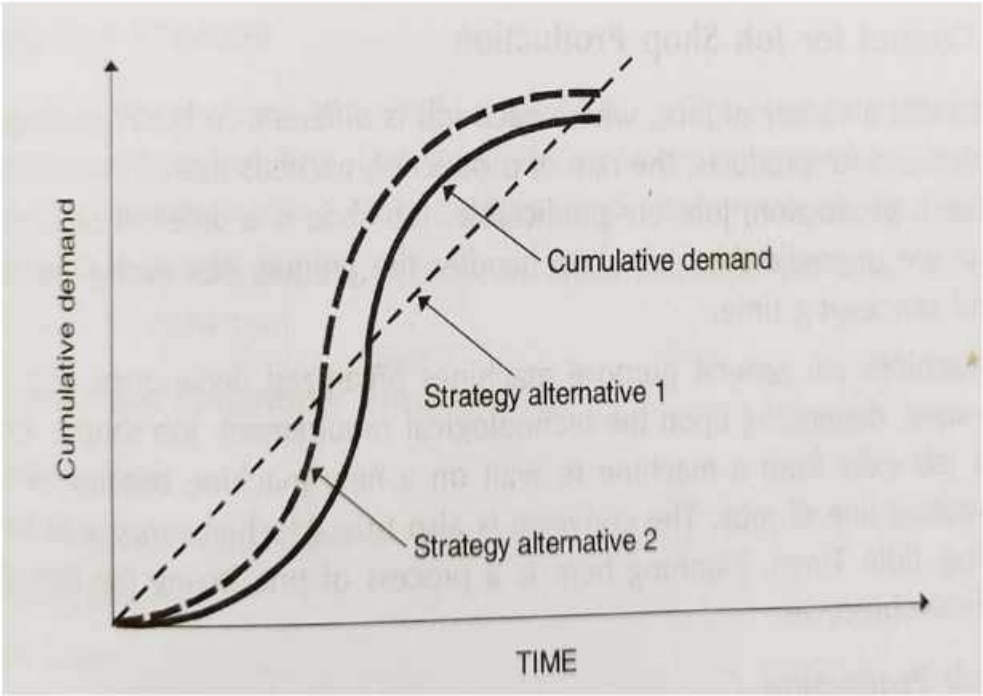

Fig : Demand Pattern : aggregate production

Strategy Alternative 1

Workforce is constant. Production output rate is therefore constant. P is however greater than D (expected demand rate in earlier production periods), CP exceeds CD. It results in a high inventory carrying cost. The converse is also true. When CD exceeds CP, there is a high shortage cost.

Strategy Alternative 2

Here, the production is adjusted to demand to minimise the inventory carrying costs. The workforce level is constantly adjusted or is paid high O.T. during peak demand periods. Both these alternatives are extreme positions. Optimum alternative minimises the total cost of the inventory and the cost of adjusting the workforce level. As a result of this exercise, we generate a master schedule where the number of units to be produced per period and the workforce level corresponding to that are described.

10.5. MATERIAL REQUIREMENT PLANNING

Keeping in mind the master schedule of the final products per period, the MRP calculates the timings of components, assembly and raw material purchasing. MRP is done with the objective to keep the work in process inventory at its minimum.'

As we have seen master schedule gives us the end products (final products) per period and the workforce levels. Given this, MRP calculates the timing of all sub-assembly, component and raw material production and purchasing activities necessary to satisfy the master schedule. MRP is done with view to minimising WIP inventory. Because of voluminous data the most MRP systems are computerized.

The process of determining components and sub-assemblies from the master schedule of end products is called Parts Explosion Requirement.

10.6. SUMMARY

- In batch production there is continuous demand for the product. The goal of calculating the optimal batch quantity of a product is that the product is produced in the required quantity and required quality at the lowest cost.
- Batch size means that the best size of the batch is decided to keep the total cost to a minimum while keeping up with the demand.
- Keeping in mind the master schedule of the final products per period, the MRP calculates the timing of components, assembly and raw material purchasing. MRP is done with the objective to keep the work in process inventory at its minimum.
- The work force and the machine allocation time is developed. Such an aggregation creates an overall production plan for all the variants of the product.

10.7. SELF-ASSESSMENT QUESTIONS

Q1. What is Batch Production and what are its merits and demerits?

Q2. How does batch size helps in keeping the cost of production minimum.

Q3. Why is an intermediate range Production Plan called an 'aggregate' Production Plan?

Q4. What is the purpose of Line of Balance for control of batch production?

Q5. What is the role of MRP in Batch Production?

10.8. SUGGESTED BOOKS/ REFERENCES

1. Chary S.N.: Production and Operations Management, McGraw Hill Education.
2. Mahajan M.: Industrial Engineering and Production Management, Dhanpat Rai& Co.
3. Chunawalla S.A., Patel D.R.: Production and Operation Management, Himalaya publishing House.

Uttar Pradesh Rajarshi Tandon Open University

Master of Business Administration

MBA-3.34

Production, Planning and Control

BLOCK

4

PRODUCT SCHEDULING OR PRODUCTION

UNIT-11

Production Control System

UNIT-12

Basic Scheduling Problems

UNIT-13

Product Sequencing

UNIT-14

Dispatching

परिशिष्ट–4

आन्तरिक कवर–दो का प्ररूप

Format of the II Inner Covers

लेखक Dr. Ekta Verma, Asst. Professor MONIRBA University of Allahabad, Prayagraj

सम्पादक Prof. J.N. Bhargawa, MONIRBA, University of Allahabad, Prayagraj.

परिमापक

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UNIT-11 PRODUCTION CONTROL SYSTEM

Unit Structure

11.0. Unit Objectives

11.1. Introduction

11.2. Concept of Scheduling

11.3. Principles of scheduling

11.4. Approaches to scheduling

11.5. Scheduling decisions

11.6. Elements of Shop floor scheduling

11.7. Loading

11.8. Master Production Schedule

11.9. Techniques of Scheduling

11.10. Summary

11.11. Self- Assessment questions

11.12. Suggested Books/ References

11.0. UNIT OBJECTIVES

In this unit, production control system, loading and scheduling, master scheduling, scheduling rules have been explained. It also gives an overview of Gantt chart.

11.1. INTRODUCTION

Operations (or production) are the process and activities for transforming resources into finished services and goods for customers. The operations function creates four kinds of utility – time utility, place utility; possess utility, and form utility – to meet customer needs.

Performing a service is different from manufacturing a good in several key ways: the raw material for service production includes the people who are seeking the service. In addition, most services are intangible, customized, and cannot be stored. Because of these characteristics, service providers generally focus on the customer service, often acknowledging the customer as part of the operations process.

Operations planning for both goods and services involve the analysis of five key factors: Capacity planning requires determining how much of a product a firm must be able to produce. Location planning involves choosing among potential facility sites. Layout planning entails designing an effective, efficient facility. Quality planning ensures that products meet a firm's quality standards. Methods planning involve identifying specific production steps and methods for performing them.

What is an operation scheduling?

Scheduling is actually concerned with establishing both the timing and the use of resources within a firm. First, keeping in view the estimated future demand of the final product, aggregate planning is done for long time horizon usually for 1-3 years. In turn, this long term plan is broken down in master production schedules for shorter time period. Master production schedule is a document that comprises of the complete information about the quantity and time of different products to be produced. On the basis of this, demand for the raw material, components etc. (known as secondary demand) are estimated under the material requirement planning system. Finally, very short term schedules are prepared which establish both the timing and the use of resources within a firm. In fact, schedules are the operations plans which are executed at lowest (shop floor) level.

Thus, schedules ensure timely production and delivery of products and the availability of required quantity of resources when they are actually required without interrupting the production. Similarly, operations control is also a mechanism which is exercised to ensure the continuous production as per the planned one.

11.2. CONCEPT OF SCHEDULING

As discussed above, the main purpose of preparing the operations schedule is to exercise the better control over the entire process. Schedules are of immense importance as far as timing and availability of adequate resources is concerned.

Some of the objectives of operations schedules have been summarized as below:

- Meet due date;
- Minimize Work in Progress (WIP) inventory;
- Minimize the average flow time through the systems;
- Provide for high machine/worker (time) utilization (minimize idle time);
- Reduce setup cost;
- Minimize production and worker costs;

- Consideration of due dates and avoiding delayed completion of job;
- Taking care of throughput time; to minimize the time a job spends in the system

11.3. PRINCIPLES OF SCHEDULING

Most of the time, scheduling is done in view of the principles:

- Schedule jobs in continuation;
- After starting a job, finish it;
- Focus on bottleneck;
- Real time feedback, real time adjustments;
- Knowledge of capacity of machines and workers;
- Continuous enhancement of product and process;

11.4. APPROACHES TO SCHEDULING

There are mainly two types of approaches which are commonly used:

i) ***Forward scheduling*** : in forward scheduling, the scheduler schedules all activities forward in time.

(a) Jobs are given earliest available time slot in operation;

(b) Usually excessive WIP results.

ii) ***Backward scheduling:*** In backward scheduling, the scheduler begins with a planned date and moves backward in time.

(a) Start with due date and work backward through operations reviewing lead times; (b) Less WIP but must have accurate lead time.

11.5. SCHEDULING DECISIONS

Whenever, different types of products are produced using the same facility, complete changeover of the system is required. Changeover is the cost of changing a processing step in a production system from one job to another. Such cost corresponds to changing machine settings, getting job instructions, changing material and changing tools.

In case of changeover, one has to be very cautious in changing the schedules also. When there is any changeover in the organization, in addition to operations schedules, the components of production system that need to be changed are as followings:

a) INPUTS : When there is a change over in a organization production system inputs are changed according to the production. Inputs include raw materials, components etc.

b) OUTPUT : When inputs are changed so automatically outputs are also changed in the production system;

c) LOGISTICS : logistics are also will be changed in the changeover of production system;

d) COST : Cost is the main factor in change-over. As cost may increase or decrease in the changeover of production system in the organization;

e) LABOUR : Labour is also important factor as which labour will do which it has to be assigned;

f) TIME : In changeover production system in an organization time factor matters the most. As it is not be same that first production done in a given time will be done as of same time in other production. The time may vary now.

11.6. ELEMENTS OF SHOP FLOOR SCHEDULING

As we know by the discussion so far, schedules are the operations plans which are executed at the lowest (shop floor) level. The classic approaches to shop floor scheduling focuses on the following elements:

a) Job arrival patterns: static or dynamic

- Static: jobs arrive in batch;
- Dynamic: jobs arrive over time interval according to some statistical distribution.

b) Numbers and variety of machines in the shop floor

- If there is only one machine or if a group of machines can be treated as one machine, the scheduling problem is much more simplified;
- As number of variety of machines increase, the more complex the scheduling problems is likely to become.

c) Ratio of workers to machines

- Machine limited system: more workers than machine or equal number workers and machines;
- Labour-limited system: more machines than worker.

d) Flow pattern of jobs: flow shop or job shop

- Flow shop: all jobs follow the same paths from one machine to the next;
- Job shop: no similar pattern of movement of jobs from one machine to the next Job sequencing
- Sequencing or priority sequencing: the process of determining which job is started first on some machines or work center by priority rule;
- Priority rule: the rule used for obtaining a job sequencing;

e) Priority rule evaluation criteria

- To meet corresponding objectives of scheduling;
- Common standard measures:
- Meeting due date of customers or downstream operations; υ
- Minimizing flow time (the time a job spends in the shop flow);

f) Minimizing WIP;

g) Minimizing idle time of machines and workers (Maximizing utilization).

11.7. LOADING

Loading is concerned with assigning jobs to work centers and corresponding to various machines in the work centers. The total time estimate to complete all the jobs at a given work center is often called the work center load. Load is often measured in time units, such as hours of work. Before discussing the methods by which loading can be done, it will be helpful to understand two fundamentally different approaches to manage a load.

Infinite Loading

In this approach, jobs are loaded into a work center according to when they need to be done with respect to customer need regardless of what the load is compared to capacity. In some respect, the jobs are loaded under the assumption the work center has almost infinite capacity (clearly not really the case). A load may look much like the diagram in Figure 11.1. The major issue with infinite loading is how to manage the load. In the case above, for example, there is little chance to do the extra week 2 load early in week 1. The manager will probably have to do something to increase the capacity temporarily in week 2, such as scheduling overtime. The overload in weeks 4 and 5 may, however, be done in week 3 since there is clearly slack capacity in that week. That is, of course, assuming that the jobs are available to be worked on early. If not, the manager may again be faced with finding capacity-expanding alternatives.

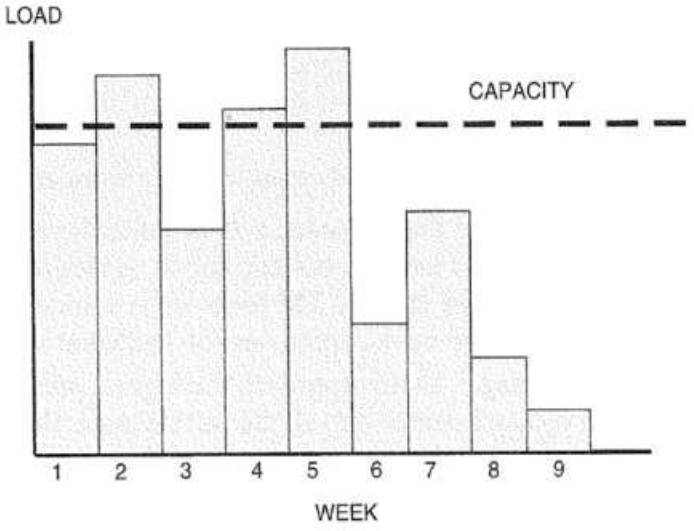


***Figure 11.1. :* "Infinite" Load example**

Finite Loading

As the name implies, this approach implies you have a known, measurable, finite capacity for the work center. There is as much loaded into the work center as possible for a given time period, then the work is moved on to the next time period since there appears to be no more capacity in the given period. This approach has gained a great deal of use in the last few years, as numerous finite scheduling software packages have been introduced. The graphical representation is in Figure 11.2.

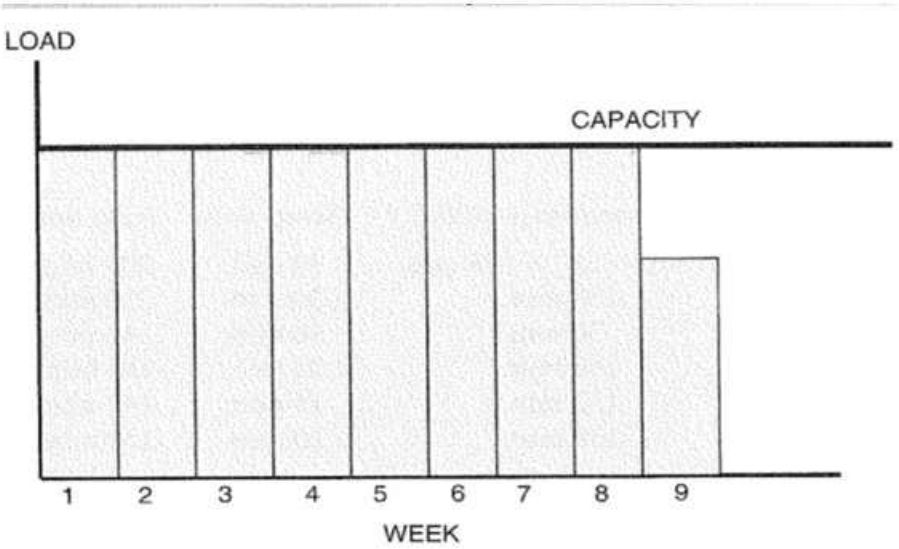


***Figure 11.2. :* "Finite" Load Example**

While this finite loading approach clearly has advantages in smoothing the load and in decreasing extra expenses from overtime and other expediting activities, there is also a clear disadvantage. Specifically, when the load is shifted to a later time period in cases when the capacity is reached, customer due dates may be adversely affected. In other words, while it may be better for the stability of the facility, it may be highly disruptive to customer service. In spite of that it is frequently used, especially in operations where adding short-term capacity is very expensive or impossible.

There are also some assumptions that must be understood before using this system. An inherent assumption with loading is that the capacity is known and accurate and the processing time for jobs is also known and accurate. Unfortunately, both those measures tend to be based on job standards that are not only somewhat subjective when developed but also change over time due to learning curves.

There are basically two methods used to load a work center:

- ***Vertical loading :*** In this approach a work center is selected and jobs are loaded into the center job by job according to a priority rule such as those described earlier in the chapter. The focus is the work center, with the job loaded work center by work center, one job loaded at a time
- ***Horizontal loading :*** In this approach the highest priority job is loaded work center by work center into all the work centers that will be required. Then the next job is loaded work center by work center, and so forth. This method is the one most commonly used by the finite scheduling systems mentioned above. The focus here is the job, with a job selected and loaded work center by work center.

11.8. MASTER PRODUCTION SCHEDULE (MPS)

Master scheduling follows aggregate planning. It expresses the overall plans in terms of specificend items or models that can be assigned priorities. It is useful to plan for the material andcapacity requirements.

Time interval used in master scheduling depends upon the type, volume, and component leadtimes of the products being produced. Normally weekly time intervals are used. The time horizoncovered by the master schedule also depends upon product characteristics and lead times. Somemaster schedules cover a period as short as few weeks and for some products it is more than a year.

Flowchart of aggregate plan and master production schedule is shown in figure below:

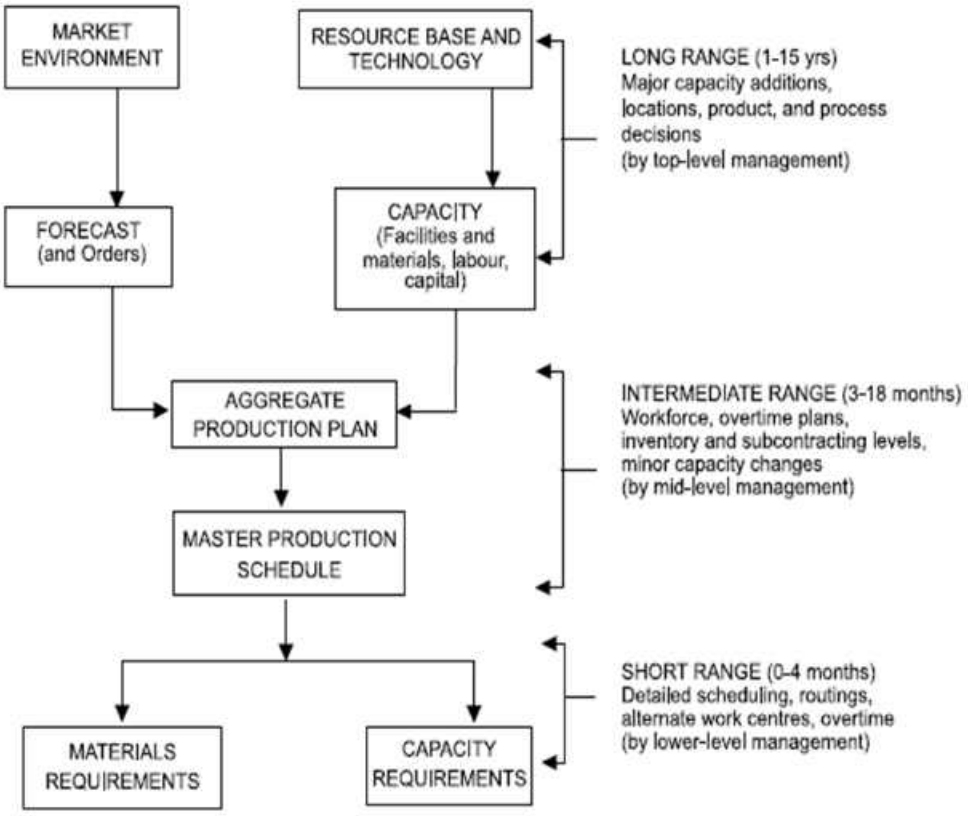


Figure 11.3 : flowchart of Aggregate Plan and Master Production Schedule

11.8.1. FUNCTIONS OF MPS

Master Production Schedule (MPS) gives formal details of the production plan and convertsthis plan into specific material and capacity requirements. The requirements with respect tolabour, material and equipment are then assessed.

The main functions of MPS are :

1. *To translate aggregate plans into specific end items*: Aggregate plan determines levelof operations that tentatively balances the market demands with the material, labour andequipment capabilities of the company. A master schedule translates this plan into specificnumber of end items to be produced in specific time period.

2. *Evaluate alternative schedules*: Master schedule is prepared by trial and error. Manycomputer simulation models are available to evaluate the alternate schedules.

3. *Generate material requirement*: It forms the basic input for material requirement planning(MRP).

4. *Generate capacity requirements*: Capacity requirements are directly derived from MPS.Master scheduling is thus a prerequisite for capacity planning.

5. *Facilitate information processing*: By controlling the load on the plant. Master scheduledetermines when the delivery should be made. It coordinates with other managementinformation systems such as, marketing, finance and personnel.

6. *Effective utilization of capacity*: By specifying end item requirements schedule establishesthe load and utilization requirements for machines and equipments.

11.9. TECHNIQUES OF SCHEDULING

The following techniques are used for scheduling:

a) Gantt Chart

b) Johnson's Two Machine Algorithm

c) Index Method

d) CPM and PERT Techniques

e) The Run out Approach

1. Gantt Charts

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

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

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

Gantt charts are of two types:

1. **Gantt load chart.** Graphically displays the work load on each machine or work centre.

2. **Gantt scheduling or progress chart.** illustrates the progress of the assigned task

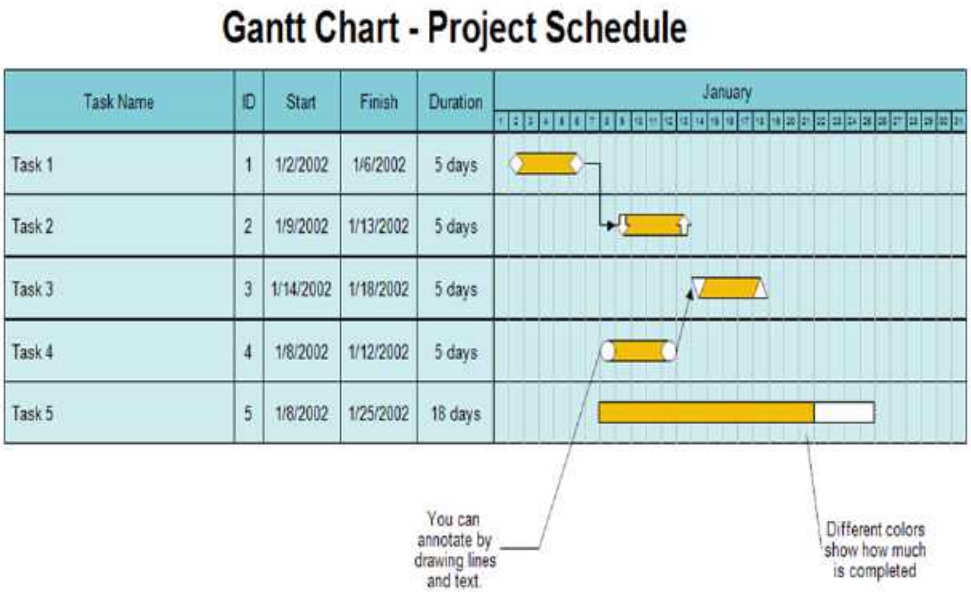


Figure 11.4: Gantt chart

Few limitations of Gantt chart are:

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

2. **Johnson's Two Machine Algorithm**

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

3. **Index Method**

- "Index Method' is a technique that can be effectively utilised for the purpose of loading and the allocation of different jobs to different machines. Normally, orders are assigned to the

best machine till it is loaded to its full capacity, remaining orders to the next best machine and so on, more or less on the principle of "first come first assigned."

- This method, however, does not result in optimum loading. A better method of machine loading, especially when there are sufficient orders and reasonable choice of machines, is to assign orders to the machines on the basis of relative effectiveness of the machines.
- Index method is a very simple technique which provides considerable improvement over the conventional methods of loading.

4. CPM and PERT Techniques

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

5. The Run out Approach

The Run out approach is applied to the process of production, which is then geared up to inventory level. It is demand oriented and aims at minimising stock-outs by assigning highest priority to those items which are likely to run out. The run out time for each time can be calculated and a monthly forecast upon the future needs can be developed. Finally, the total number of months that

may elapse before the total inventory will run out is calculated. This method is simple, easy, and economical. It helps in minimizing stock outs and contributes towards improving the consumer service. Hence, it is widely used in modern manufacturing organisations.

11.10. SUMMARY

- The operations function creates four kinds of utility – time utility, place utility; possess utility, and form utility – to meet customer needs.
- Master production schedule is a document that comprises of the complete information about the quantity and time of different products to be produced. On the basis of this, demand for the raw material, components etc. (known as secondary demand) are estimated under the material requirement planning system.
- There are two basic approaches to establishing these time estimates. Thefirst, called backward scheduling, starts the calculation from the time the job isdue (or has been promised), and uses lead time information to work backwardto determine when the job should reach and be completed by each work center. The second, called forward scheduling, is essentially the opposite.
- The total time estimate to complete all the jobs at a given work center is often called the work center load. Load is often measured in time units, such as hours of work.
- Master scheduling follows aggregate planning. It expresses the overall plans in terms of specificend items or models that can be assigned priorities. It is useful to plan for the material andcapacity requirements.
- When a project is in progress, Gantt Charts help to supervise whether the project is on schedule. If it is not, it suggests the remedial action necessary to put it back on schedule.
- According to Johnson's rules, the job operations are arranged on the two machines in the order of their processing time, depending on shortest processing time and so forth.
- "Index Method' is a technique that can be effectively utilised for the purpose of loading and the allocation of different jobs to different machines. Normally, orders are assigned to the best machine till it is loaded to its full capacity, remaining orders to the next best machine and so on, more or less on the principle of "first come first assigned."
- CPM can be used to schedule the activities of simple projects like overhauling of a machine, purchase and installation of a new

machine, construction of a small shed. And at the other extreme end, it can be used for large complicated projects like design, production and testing of prototype of an aircraft requiring co-ordination, scheduling and control of activities of many different specialist teams, sub-contractor and purchasing agents.

- The Programme Evaluation Review Technique (PERT) technique provides a measure of the probability of completing the project by the scheduled date. In PERT, the assessment of the end event of the project is related to the degree of uncertainty that is associated with the three time estimates.
- The Run out approach is applied to the process of production, which is then geared up to inventory level. It is demand oriented and aims at minimising stock-outs by assigning highest priority to those items which are likely to run out.

11.11. SELF-ASSESSMENT QUESTIONS

Q1. What is the aim of Production control System?

Q2. What is an operation scheduling and what are itsobjectives?

Q3. Outline the principles of scheduling. Discuss the approaches used in scheduling.

Q4. What is the impact of scheduling decision on Production Control system?

Q5. Discuss the use of Gantt chart for scheduling purpose.

Q6. Differentiate between Loading and Scheduling. Is a clear cut distinction between the two, possible under all production situations?

11.12. SUGGESTED BOOKS/ REFERENCES

1. Chary S.N.: Production and Operations Management, McGraw Hill Education
2. Mahajan M.: Industrial Engineering and Production Management, Dhanpat Rai & Co.

UNIT-12 BASIC SCHEDULING PROBLEMS

Unit Structure

12.0. Unit Objectives

12.1. Introduction

12.2. Production Planning Scheduling Problem

12.3. Production environment

12.4. Complexities in the production environment

12.5. Production planning schedule decisions

12.6. Line of balance

12.7. Summary

12.8. Self-Assessment questions

12.9. Suggested Books/ References

12.0. UNIT OBJECTIVES

This unit aims at providing basic scheduling problems. Also explains the fundamental of line of balance.

12.1. INTRODUCTION

Today's business environment has become highly competitive. Manufacturing firms have started recognizing the importance of manufacturing strategy in their businesses. Firms are increasingly facing external pressures to improve customer response time, increase product offerings, manage demand variability and be price competitive. In order to meet these challenges, firms often find themselves in situations with critical shortages of some products and excess inventories of other products. This raises the issue of finding the right balance between cutting costs and maintaining customer responsiveness. Firms are facing internal pressures to increase profitability through improvements in manufacturing efficiency and reductions in operational costs.

There are several instances in industry where the above-mentioned changes in business environment have affected the profitability of firms.They had to provide competitive ontime delivery performance over a much greater product mix. Their inefficient handling of a large product variety resulted in late deliveries and lost sales.

Production planning and scheduling help considerably in reducing operational costs, improving customer service and utilizing the resources optimally. By applying optimization based productionplanning system, companies have raised its on-time deliveries from 75 to 95% without increasing inventories and converted its huge losses to an annual profit $40 million. Over the past two decades, IBM's operations research team developed production-planning systems and helped save hundreds of millions of dollars, while improving operations and competitive strategies. H&R Johnson implemented production-planning tools and reduced its production lead times and inventory costs.

Production planning and scheduling find their applicability in both discrete parts manufacturing and process industries. APICS (American Production and Inventory Control Society) dictionary provides the key elements to classify industries as process or discrete parts. More and more process industries are shifting to specialties market with customized products and are no longer operating on make-to-stock policy alone. This is especially true of batch process industries such as pharmaceuticals, food, and glass, etc. These industries do not restrict themselves to commodity products only. The first significant applications of production planning and scheduling methods in process industries were in oil refineries, food processing and steel manufacturing. Through the years, production planning and scheduling methods have been developed and applied to process manufacturing of other products such as chemicals, paper, soap and industrial gases.

12.2. PRODUCTION PLANNING AND SCHEDULING PROBLEM

The production planning and scheduling problem is addressed in the following three sections:

i. Production environment.

ii. Complexities in the production environment

iii. Production planning and scheduling problem.

12.3. PRODUCTION ENVIRONMENT

We consider multi-stage production environment that produces both intermediate products and finished goods. A stage in the production environment corresponds to the production of an intermediate product or a finished good. The concept of multi-stage in the environment considered is equivalent to the multi-level product structure, as shown below for illustration in figure 2.1. In figure 112.1, level 0 products are finished goods (E1, E2, and E3), level 1 and level 2 products are intermediate products (I1, I2…I6). The levels in the product structure diagram are various stages of the production process. For instance, level 1 and level 2

in figure 12.1 are the intermediate products stages. The intermediate products at level 2 are inputs to the intermediate products at level 1. Level 1 intermediate products are inputs to level 0 products, which are finished goods, and at the finished goods production stage. products at level 1. Level 1 intermediate productsare inputs to level 0 products, which are finished goods, and at the finished goods production stage.

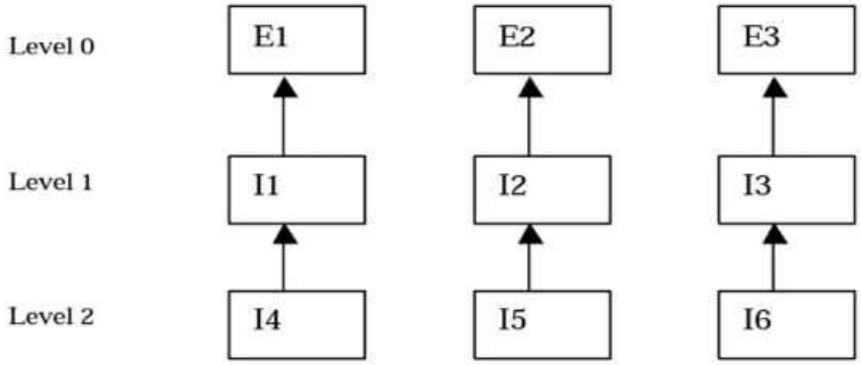


Figure 12.1 : Multi-level Product Structure and Concept of Stage

The production environment has multiple production plants to produce intermediate products and finished goods. A production plant consists of number of equipment, called as 'machines'. Intermediate products and finished goods are processed on machines in a production plant in a specific order. The processing of a product on a machine is called an 'operation'. A 'route' is defined as the sequence of machines used for processing a product. To illustrate these concepts, figure 12.2 below. Consider a product 'P', it requires four operations in a production plant. There are five machines in the plant in this example (M1, M2...M5). As indicated in figure 12.2, there is choice of machines between M3 and M4 for third operation. That is, based on the machine used for third operation of product P, there are two different routes, Route 1 and Route 2 to produce product P. Route 1 comprises machines M1, M2, M3, M5 and Route 2 comprises machines M1, M2, M4 and M5.

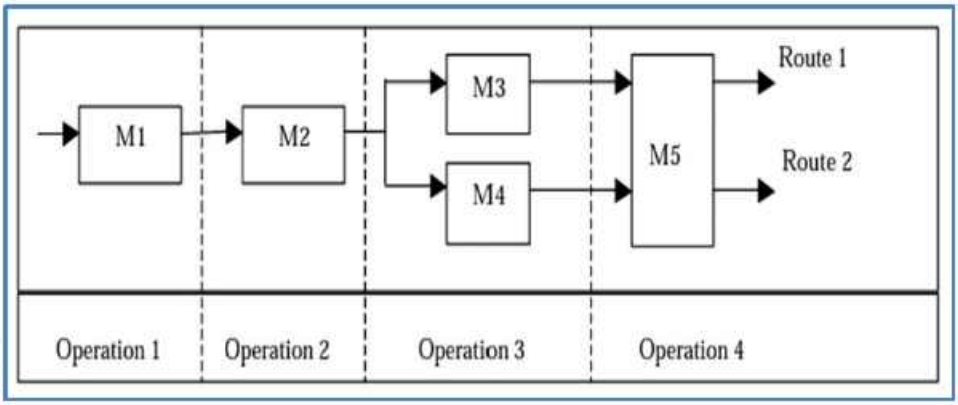


Figure 12.2 : Machines, Operations and Routes of a Product

There are two types of production plants in the production process. One is the dedicated production plant. In the dedicated production plant, only one type of product is produced. The second type is the flexible plant. In the flexible production plant, intermediate products and finished goods share machines.

A by-product is generated, when an intermediate product or a finished good is produced in a production plant. A by-product consists of reusable raw materials. By products are processed in a separate recycling plant, and some reusable raw materials are recovered from the recycling process. Part of the raw materials that is not recovered for reuse becomes waste. Figure 12.3 shows the inputs and outputs of the production process and linkages between the production plants and the recycling plants.

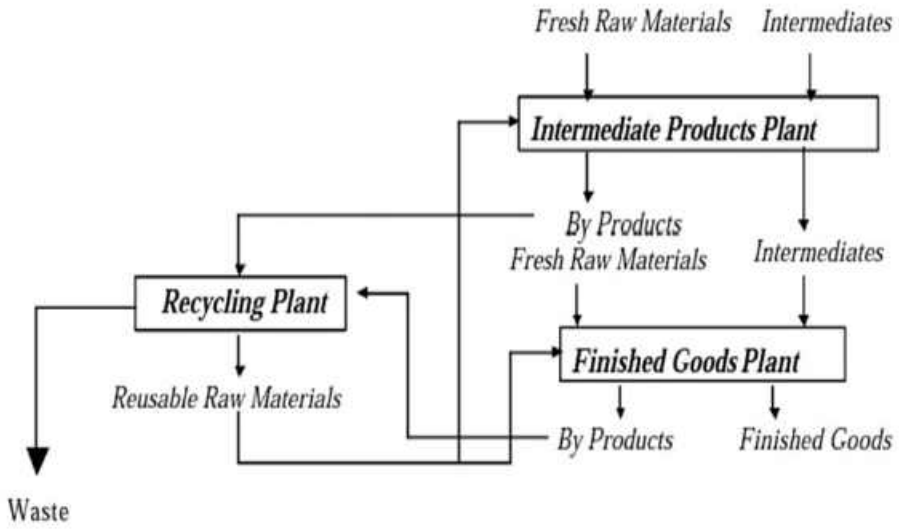


Figure 12.3: Inputs and Outputs of a Production Process

It can be seen in figure 12.3 that inputs to production process in a plant are the fresh raw materials, reusable raw materials and intermediate products. The outputs of a production process from a plant are intermediate products, finished goods and by-products. By-products are processed in recycling plants to recover reusable raw materials. Reusable raw materials are used again as inputs in the production process.

Flowshop setting for the finished goods in the production environment is considered important. In a flowshop, all products follow a similar route in a production plant. Intermediate products follow a general job shop setting with re-entrant flows. In a general job shop, the routes of products are distinct. The characteristic of a re-entrant job shop is that jobs are processed on a particular machine for more than one operation.

12.4. COMPLEXITIES IN THE PRODUCTION ENVIRONMENT

In this sub-section, we describe some of the complexities that exist in the production environment. The production environment discussed in previous sub-section, and the complexities in the production environment, form the basis for production planning and scheduling decisions.

As seen in figure 12.3, raw materials are recovered from by-products through a recycling process and reused in the production process. The recycling process is an important tool in reducing the operational costs, as the cost of raw materials is very high. Maximum recovery of the raw materials would translate to less use of fresh raw materials in the production process. It is desirable to run the recycling plants when the production plants are in operation. The reason for this argument is that by-products and reusable raw materials have limited storage capacity. Simultaneous generation and recycling of by-products would minimize the storage of by-products and recovered raw materials. This also translates into maintaining lesser inventory of fresh raw materials, because more reusable raw materials are being used in the production process. The above discussion leads to requirement of coordinating the production process and the recycling process. The production plans of the plants should be synchronized with the recycling plants to reduce the operational costs.

In a multi-stage environment, inventory is in the form of intermediate products and finished goods. To minimize production costs, inventory of the products needs to be minimized. This objective results in complexity of coordinating the schedules of products across the production plants. If production plants were decoupled with each other while scheduling, considerably high amount of inventory would be required to avoid production delays. When an intermediate product or an end product is scheduled, intermediate products that are inputs to the product should be available. Inventory of products will be reduced if the production plants are synchronized, i.e., when an intermediate product is produced, its higher-level product (where it is an input) is ready for processing. Similarly, the availability of raw materials with their minimum inventory is to be ensured before scheduling products.

There are high setup times in the production process. During product changeover at a flexible machine, idle time is incurred. In chemical plants, because of the chemical properties of products, residues have to be removed thoroughly at each change over, and these results in considerable amount of idle time. There are trade-offs between setup costs and inventory costs. Higher production run of a product in a setup would result in high inventory cost, whereas more number of setups would consume significant amount of capacity in setups.

Intermediate products and finished goods are perishable. They have to be consumed within a specific time period, else they become

waste. To minimize wastage and to avoid any production delays resulting from wastage, production plans at the plants need to be synchronized based on the shelf life of products.

Intermediate products are transferred to another production plant or within the same production plant, for next stage production, through transfer lot size of products. Only after certain quantity specified by the transfer lot size is produced, the product is transferred for its consumption. This again leads to the requirement of coordinating the production plants on the basis of transfer lot sizes.

There is also a trade-off between purchasing the intermediate products and their in-house production. The implications of purchasing the intermediate products are twofold. Purchasing would obviously result in higher production costs, but this also can help in minimizing production delays.

Demand variability adds to the complexity in the system. The production planning is done on the basis of combination of firm orders and demand forecast over a finite planning horizon. The implication of demand variability is that if the demand forecast is not correct, there would be high inventory levels of some products and stock outs of other products. Another implication of demand fluctuation is that within the planning period, frequent revision in production plan and schedule is required to absorb the variation in demand.

12.5. PRODUCTION PLANNING AND SCHEDULING DECISIONS

In this sub-section, we characterize the production planning and scheduling problem based on the decisions to be addressed in the problem. There are two sets of decisions in the problem. One set of decisions is the production planning decisions. The other set is the scheduling decisions.

Production planning decisions are aggregate decisions and tactical in nature. One of the production planning decisions is to determine the production quantity of intermediate products and finished goods in each time period of the planning horizon. Production planning also determines the aggregate capacity of resources required to meet the production plan in each time period is to be determined. The production planning costs are the inventory costs of products and setup costs incurred over the planning horizon. The production-planning problem is to determine the decisions discussed above at minimum cost.

Scheduling decisions are more detailed and operational in nature. The time horizon of scheduling decisions is relatively short. For each product, the start time and the completion time on each machine is to be determined. The scheduling cost consists of inventory costs and costs incurred due to delay in satisfying customer orders.. The scheduling problem is to determine the scheduling decisions at minimum cost.

Manufacturers are dealing with deterministic scheduling, i.e., at the time of scheduling, all the information that defines a problem instance is known with certainty. The information lending the scheduling problem to be deterministic, for example, is the known processing time of products, and machine availability.

12.6. LINE OF BALANCE

Line of Balance (LOB) is a management control process for collecting, measuring and presenting facts relating to time (see Schedule Control), cost and accomplishment – all measured against a specific plan. It shows the process, status, background, timing and phasing of the project activities, thus providing management with measuring tools that help:

- Comparing actual progress with a formal objective plan.
- Examining only the deviations from established plans, and gauging their degree of severity with respect to the remainder of the project.
- Receiving timely information concerning trouble areas and indicating areas where appropriate corrective action is required.
- Forecasting future performance.

The LOB itself is a graphic device that enables a manager to see at a single glance which activities of an operation are "in balance" – i.e., whether those which should have been completed at the time of the review actually are completed and whether any activities scheduled for future completion are lagging behind schedule. The LOB chart comprises only one feature of the whole philosophy which includes numerous danger signal controls for all the various levels of management concerned.

To do LOB, the following is needed:

- A contract schedule, or objective chart;
- A production plan or lead-time chart for the production process itself;
- Control points cumulative inventories; and
- A program status chart on which to plot LOB and the cumulative quantities of units that have passed through the control points of the assembly/production process.

12.7. SUMMARY

- Production planning and scheduling help considerably in reducing operational costs, improving customer service and utilizing the resources optimally.

- A production plant consists of number of equipment, called as 'machines'. Intermediate products and finished goods are processed on machines in a production plant in a specific order. The processing of a product on a machine is called an 'operation'. A 'route' is defined as the sequence of machines used for processing a product.

- A by-product is generated, when an intermediate product or a finished good is produced in a production plant. A by-product consists of reusable raw materials. By products are processed in a separate recycling plant, and some reusable raw materials are recovered from the recycling process.

- Flowshop setting for the finished goods in the production environment is considered important. In a flowshop, all products follow a similar route in a production plant. Intermediate products follow a general job shop setting with re-entrant flows.

- The recycling process is an important tool in reducing the operational costs, as the cost of raw materials is very high. Maximum recovery of the raw materials would translate to less use of fresh raw materials in the production process. It is desirable to run the recycling plants when the production plants are in operation.

- The scheduling problem is to determine the scheduling decisions at minimum cost. Manufacturers are dealing with deterministic scheduling, i.e., at the time of scheduling, all the information that defines a problem instance is known with certainty.

- Line of Balance (LOB) is a management control process for collecting, measuring and presenting facts relating to time (see Schedule Control), cost and accomplishment – all measured against a specific plan.

12.8. SELF - ASSESSMENT QUESTIONS

Q1. What are the scheduling problems in Line Production?

Q2. What are the complexities in the Production environment of scheduling?

Q3. Why flowshop setting in the production environment is considered important?

Q4. How production planning decisions helps in solving scheduling problems?

Q5. Would the Line of Balance technique be more useful to the General Manager (Production) or to a plant superintendent? Explain.

16.9. SUGGESTED BOOKS/ REFERENCES

1. Chary S.N.: Production and Operations Management, McGraw Hill Education

2. Mahajan M.: Industrial Engineering and Production Management, Dhanpat Rai & Co.

UNIT-13 PRODUCT SEQUENCING

Unit Structure

13.0. Unit Objectives

13.1. Sequencing

13.2. Benefit of Flexis sequencing

13.3. Priority sequencing rules

13.4. Material Requirement planning

13.5. Benefit of MRP system

13.6. Kanban

13.7. Summary

13.8. Self-Assessment Questions

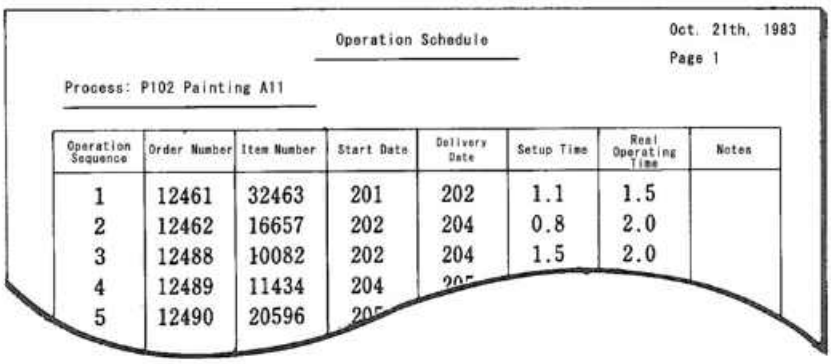
13.9. Suggested Books/ References

13.0. UNIT OBJECTIVES

This unit deals with production sequencing, product control system, its importance, utility, merits and demerits. It also explains about period batch control- material requirement planning and Kanban.

13.1. SEQUENCING

Sequencing refers to the order in which activities occur in the operations process. The operations manager constantly analyses the sequencing to improve the efficiency of the business. It is to plan the order of the operation by process, regarding the fixed orders through the Operation Order Release Planning. It is to grasp the progress status of the operation, to consider the priority, setup time, and etc., and to make an operation sequencing list.



Operation Schedule

Oct. 21th, 1983

Page 1

Process: P102 Painting A11

Operation Sequence	Order Number	Item Number	Start Date	Delivery Date	Setup Time	Real Operating Time	Notes
1	12461	32463	201	202	1.1	1.5	
2	12462	16657	202	204	0.8	2.0	
3	12488	10082	202	204	1.5	2.0	
4	12489	11434	204	20[illegible]			
5	12490	20596	20[illegible]				

Figure 13.1: Operation schedule

13.1.1. OPTIMAL PRODUCTION SEQUENCE – EFFICIENT, ADAPTABLE, AND INDIVIDUALLY CONFIGURABLE

Sequence Planning is the creation of an optimized assembly sequence that takes into account all of the production and supply restrictions. The production sequence helps to avoid bottleneck situations while maximizing the use of available resources. Sequencing helps to form the basis from which it is possible to produce utilizing the pearl chain concept.

13.2. BENEFITS OF FLEXIS SEQUENCING

The assembly and production areas of a variant rich organization are subject to constant changes. By making changes to the product or process, the requirements for order planning are constantly being updated. Flexis Sequencing allows the planner the freedom to define rules based on how orders were created, customized, and configured. The option of creating new custom rules or generating rules based on a standard rule library to adapt to new production conditions is available. Additional rules such as distance conditions can be used in flexis sequencing as well. This higher level of transparency and optimized planning creates a holistic optimization and reduces the risk of bottlenecks and other production disturbances.

The aim of an optimized sequence is the uniform distribution of the assembly operation and the assembly time. In contrast to other solutions on the market, flexis sequencing solutions defines respective rules based on properties of the vehicle (such as different types of drive) which can then be dissected deeper within a flexis system for another level of constraint application.

- Continuous planning from order analysis and selection to sequencing
- Sequencing based off of configurable standard rules/constraint templates
- Rules based on all contract features such as commitments, equipment attributes, assembly allocation
- Calculate an exact schedule timeline for the sequence
- Visualization of rule violations, real-time updates to manual changes
- Final analysis of results with the ability to calculate mounting times
- Productivity Increase of 2-5% through smoothing of the production program

- Simplified planning and post-planning results in a 20-60% increase in productivity
- Reduced Capital investment through lower safety stock requirements of 30-50%
- Reduce Rework- "high pearl chain good", average reductions of 30-50% are possible.

13.3. PRIORITY SEQUENCING RULES

For discrete manufacturing, there are a number of sequencing rules that can be used to prioritise jobs on shared machines. There are at least four popular priority rules for sequencing jobs.

- First Come, First Served (FCFS) priority rule, where jobs are assigned to a shared resource in the order in which they are placed.
- Shortest Processing Time (SPT), where jobs are ordered based on the length of the processing time, and the jobs with the shortest processing time are ordered first.
- Longest Processing Time (LPT), where, jobs with the longest processing time are ordered first.
- Earliest Due Date (EDD), where jobs are ordered based on their required delivery dates, and the jobs with the earliest due dates are ordered fist on the shared resource.

13.4. MATERIAL REQUIREMENT PLANNING

Material Requirements Planning is basically concerned with the inventory of rawmaterials and components which are required to produce the products in a facility. The demand for raw materials and components is termed as secondary demand which is essentially depending upon the demand for the finished products. At current, globalization of the economy and the liberalization of the trade markets have created new conditions in the market place which are characterized by turbulence and intensive competition in the business environment. Competition is continuously growing with respect to price, quality and selection, service and promptness of delivery. Removal of barriers, international cooperation, technological innovations naturally cause competition to Intensify. In terms of manufacturing emphasis is placed on reducing cost while improving quality. In addition, other factors such as timely delivery of the product become critical (this is captured by emphasis in Just in Time or JIT in short) techniques.

It is a time phased priority-planning technique that estimates material requirements and schedules supply to meet demand across all products and parts in one or more plants. MRP techniques are used to

explode bills of material, to compute net material requirements and plan future production.

Information Technology plays a major role in designing and implementing Material Requirements Planning systems and processes as it provides information about manufacturing needs (linked with customer demand) as well as information about inventory levels. MRP techniques focus on optimizing inventory.

MRP systems mainly use following information to determine what material should be ordered and when:

- The master production schedule, which describes when each product is scheduled to be manufactured;
- Bill of materials, which lists exactly the parts or materials required to make each product;
- Production cycle times and material needs at each stage of the production cycle time;
- Supplier lead -times.

In figure below, you can see the overall view of the Inputs to a Standard Material Requirements system and the various reports generated by the system which are of immense importance for the production managers.

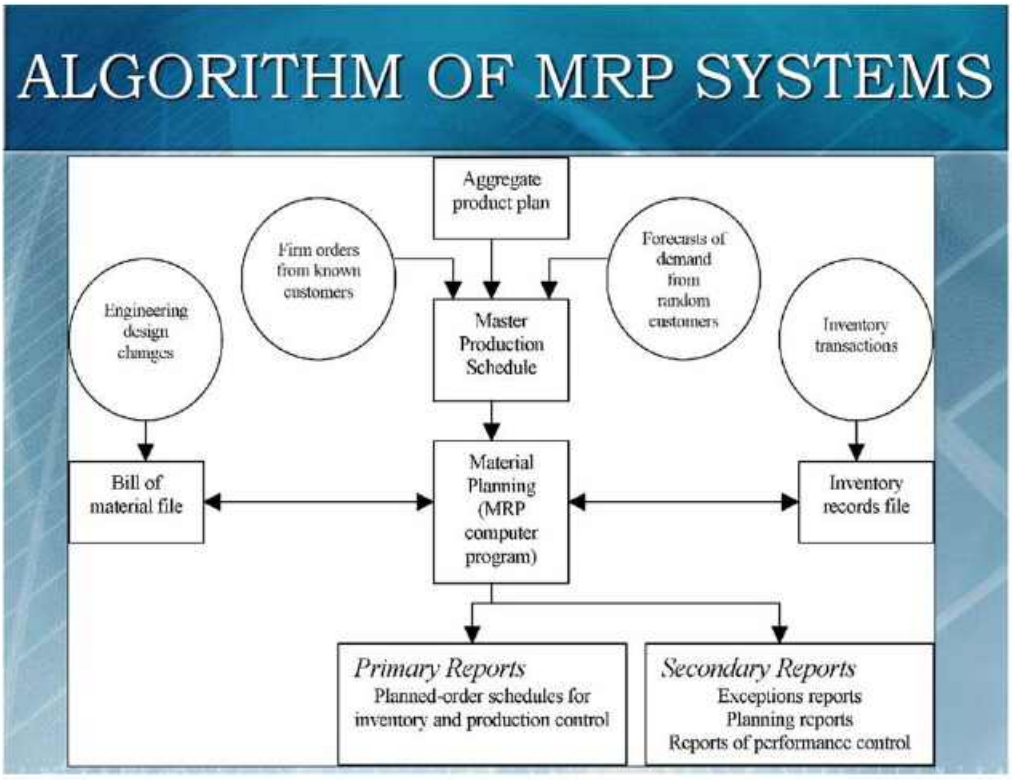


Figure 13.2 : MRP System

The master schedule and bill of materials indicate what materials should be ordered; the master schedule, production cycle times and supplier lead times then jointly determine when orders need to be placed.

The Master Production Schedule includes quantities of products to be produced at a given time period. Quantities are included both at aggregate and detailed levels. Aggregate may refer to monthly production and detailed may refer to weekly or daily production. The master production schedule is a tabular form in which rows represent products and columns represent time components.

Bill of Materials gives information about the product structure, i.e., parts and raw material units necessary to manufacture one unit of the product of interest (discussed in next section of this chapter). MRP was pioneered in the 1970's with the work of Orlicky. Later evolved or became part of integrated to Manufacturing Resource Planning systems (or MRPII). MRPII is a computer based planning and scheduling system designed to improve management's control of manufacturing and its support functions.

13.5. BENEFITS OF MRP SYSTEM

MRP system is of immense importance in manufacturing organizations. The key benefits have been summarized as below:

- Reduced inventories without reduced customer service
- Ability to track material requirements
- Ability to evaluate capacity requirements
- Means of allocating production time
- Increased customer satisfaction due to meeting delivery schedules
- Faster response to market changes
- Improved labour and equipment utilization
- Better inventory planning and scheduling.
- In addition to above, the key outputs of MRP system are very helpful in:
- Calculating demand for component items
- Determining requirements for subassemblies, components, and raw material
- Determining when they are needed
- Generating work orders and purchase order
- Considering lead time.

13.6. KANBAN

Kanban is a Japanese word that means flag or signal, and is a visual aid to convey the message that action is required. The kanban inventory control system was originally introduced by the Toyota motor company in Japan. On a visit to the USA, Toyota's Vice President Taiichi Ohno noticed the technique, adapted by American supermarkets for replenishing empty shelves in racks .Whenever a shelf was found drained of a product, it triggered the replenishment of the product to the shelf. It was so simple because an empty shelf was easily visible among the other shelves full of products. Ohno thought of implementing the same idea for replenishment at his assembly lines. He adapted this simple but effective method by using a trigger or kanban, to alert the manufacturing area that the assembly area was running low on components. Every component must have its own kanban to signal when it needs to be replenished.

The kanban system can be explained in the following stages:

Stage 1 When a worker needs components, he goes to the racks placed opposite his workstation. These racks contain bins of components required by a workstation, which from the work in process inventory. Every bin has the requisition kanban card affixed on it, which is removable .This card contains the component name, its identification number, and the rack number and shelf on the rack in the store where more bins of the component are stored. The workers from the assembly line remove the kanban card from the bin, hang it on a hook on the rack, and take away the bin to their workstation for using the components in assembly operations. These hanging kanban cards are thus clearly visible from everywhere, signalling replenishment of components from the store.

Stage 2 A supply worker called "Mizosomashi" in Japanese keeps on moving in the aisle or the passage way across the racks his trolley. When he reaches the racks opposite the assembly line, he removes all the hanging requisition kanban cards and the empty bins from the racks. He then takes these along with him through the aisle to the racks in the store opposite the manufacturing cells.

Stage 3 Mizosomashi looks at the information on each requisition kanban card and locates the position of the rack and the shelf on the rack containing the bins full of a particular component .Every bin in the store has the production kanban card affixed on it, which is removable. The production kanban card contains the name and identification number of the component to be manufactured in the cell. Mizosomashi takes off the bins from the racks corresponding to the requisition kanban card he had bought with him, and removes the production kanban card from these. He hangs these on the hooks on the corresponding racks in the store, attaches the requisition kanban cards on the bins, and puts the bins in the trolley to the racks opposite the assembly line and places the bins in the appropriate racks. Thus, the replenishment of the bins at the assembly line has taken place. Mizosomashi repeats this process at regular intervals of time.

Stage 4 One worker from each of the manufacturing cells goes to the rack placed opposite his cell with his trolley. He removes the hanging production kanban cards and places the empty bins from the rack in his trolley. He takes these to his manufacturing cell, where the different components mentioned on the production kanban cards are manufactured in exact quantities so as to fill the empty bins completely. The filled in bins with the production kanban cards attached to them are then taken from the manufacturing cell to the rack opposite the cell and placed on the appropriate shelf mentioned in the production kanban card. JIT is a pull system, as opposed to the western norm of making bulk components and storing them just in case they are needed. The obvious benefits of using the kanban system are reduced inventory and less storage space required; however, the hidden benefit is the high quality of components. Production of components in small batches makes it easier to immediately detect defects in them. Thus reduced inventory acts as a buffer against bad quality.

13.7. SUMMARY

- Flexis Sequencing allows the planner the freedom to define rules based on how orders were created, customized, and configured.
- Material Requirements Planning is basically concerned with the inventory of rawmaterials and components which are required to produce the products in a facility.
- MRP techniques are used to explode bills of material, to compute net material requirements and plan future production.
- The Master Production Schedule includes quantities of products to be produced at a given time period. Aggregate quantities refers to monthly production and detailed may refer to weekly or daily production. The master production schedule is a tabular form in which rows represent products and columns represent time components.
- Bill of Materials gives information about the product structure, i.e., parts and raw material units necessary to manufacture one unit of the product of interest.
- Kanban is a Japanese word that means flag or signal, and is a visual aid to convey the message that action is requiredfor replenishment at his assembly lines.
- The benefits of using the kanban system are reduced inventory and the hidden benefit is the high quality of components. Production of components in small batches makes it easier to immediately detect defects in them. Thus reduced inventory acts as a buffer against bad quality.

13.8. SELF-ASSESSMENT QUESTIONS

Q1. Explain the concept of Sequencing.

Q2. Flexi sequencing defines the rules based on how orders were created, customized and configured. Explain.

Q3. Discuss the priority rules set for sequencing.

Q4. What is Material Requirement Planning (MRP)? What are its merits and demerits?

Q5. Explain the functional system of MRP.

Q6. What is Kanban Inventory Control System? Explain the stages involved in this system.

13.9. SUGGESTED BOOKS/ REFERENCES

1. Chary S.N.: Production and Operations Management, McGraw Hill Education
2. Mahajan M.: Industrial Engineering and Production Management, DhanpatRai& Co.

UNIT-14 DISPATCHING

Unit Structure

14.0. Unit Objectives

14.1. Introduction

14.2. Functions of dispatching

14.3. Dispatching Procedure

14.4. Meaning of Follow up

14.5. Function and purpose of Follow up

14.6. Application of computer in production planning and control

14.7. Summary

14.8. Self-Assessment Questions

14.9. Suggested Books/ References

14.0. UNIT OBJECTIVES

This unit gives a detailed description of despatching- progress reporting and expediting and also deals with techniques aligning completion times and due dates.

14.1. INTRODUCTION

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

In other words, once a job is in an area where an operation is to be performed, it has to be determined when and by whom the job will be processed and also the sequence of waiting orders to be processed. The decision of assigning the various jobs to different machines and equipment is called Dispatching.

14.2. FUNCTIONS OF DISPATCHING

- To check the availability of input materials and ensure the movement of material from store to first process and then from process to process.

- To ensure the availability of all production and inspection aids.
- To obtain the requisite drawings, specifications and material lists.
- To assign the work appropriate machine, workplace and men.
- The issue of job orders authorizing operations in accordance with dates and times previously planned and entered on load charts and route sheets.
- The issue of time tickets, instruction cards and other required items to the workers who are to perform the various activities.
- The issue of inspection orders after each operation in order to determine result regarding the quality of products if excessive spoilage occurs, to find out its causes.
- Clean up on jobs, collection of time tickets, blueprints and instruction cards and their return to appropriate section of production control department.
- To ensure that the work is forwarded to next department or storeroom etc.
- To record the beginning and completion times of jobs on time tickets for calculation of time interval. To forward time ticket to accounts department for preparing wages.
- To record and report idle time of men and machines and request for corrective action required.

14.3. DISPATCHING PROCEDURE

In the decentralized dispatching, the manufacturing orders are issued in blanket way to the Engineer/Foreman/Supervisor. He must then determine the relative sequence in which these orders will be taken up within the department.

It is the duty of the person (may be Foreman/Supervisor) concerned to dispatch these orders and to ensure that the required material is available at each machine and operator. In such cases the dispatch of material must be completed in the department on or before the prescribed date.

Chart in Fig.14.1 illustrates the sequence of dispatching operation for intermittent manufacturing system from the issue of manufacturing orders to the end of dispatching operation.

From the manufacturing order list of assemblies, sub-assemblies and parts is prepared.

Route sheets are prepared for various components/parts and assemblies etc.

These route sheets indicate the input materials operation to be performed and their sequence. Further the time allowances are entered against each operation along with the date when it should start and finish. Along-with details of tools, jigs and fixtures required.

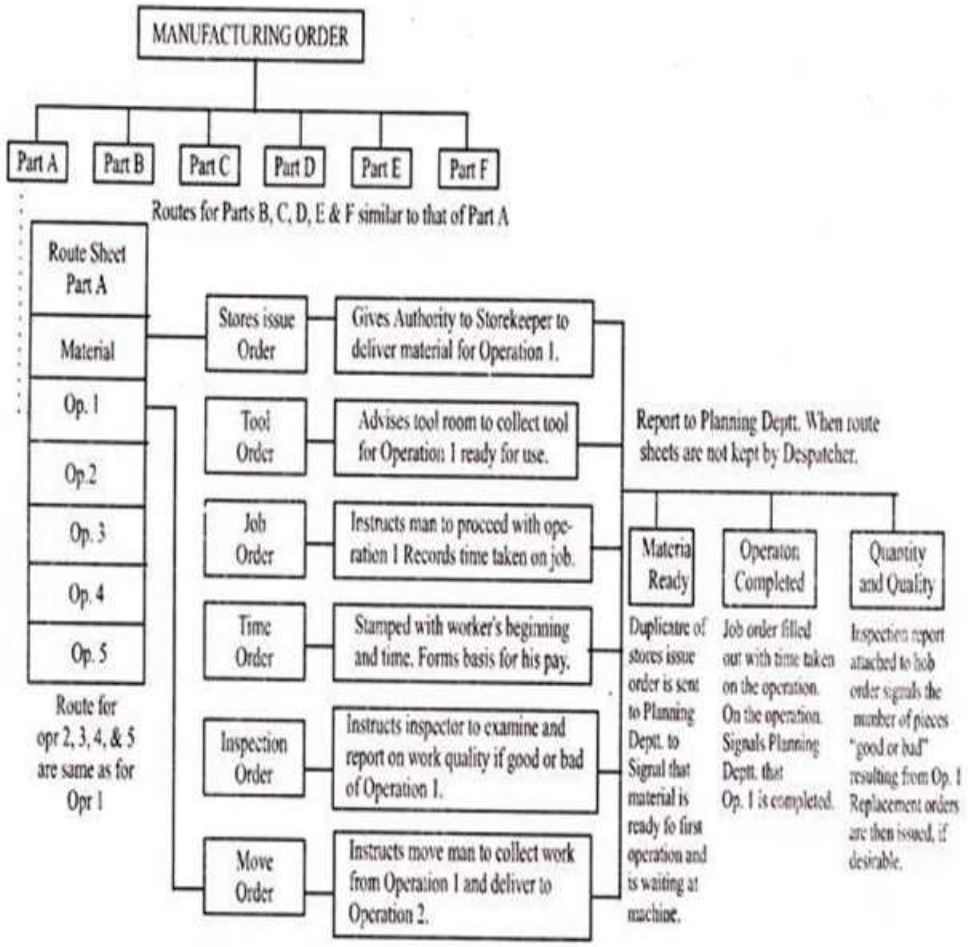


Fig. 7.14. Chart showing the sequence of dispatching operaton for intermittent manufacture.

Figure 14.1 : The sequence of dispatching operation for intermittent manufacture.

The blue prints supplies the limits and tolerances for the purpose of inspection. In order to give effect to this information, required materials, tools, job orders, inspection tickets and move orders are prepared. So, all working papers should be ready a day or two before the job should start.

These are further made available to the various persons concerned by the dispatcher.

The material, tools and jigs & fixtures will be issued to the machine operators.

Inspection shall be performed after the first operation is over and the part shall move to next work station for second operation if it passes inspection.

The purpose of decentralized dispatching is to minimize the duplication of postings and elaborate reporting etc. In centralized dispatching which is applicable forcontinuous manufacturing system that involves a single standardized product and no assembly, dispatching requires that the concerned shops be informed about the decided rate of production.

The routine of dispatching under these circumstances shall be quite different from decentralized dispatching discussed earlier. This is called centralized control.

This system involves the dispatching orders from the central dispatching division directly to work stations. The working capacity & other characteristics of the machines/equipment as well as the back log and work ahead of it are known and recorded in the central dispatch office. In this case the whole dispatching is controlled from that point.

In both types of dispatching, it is traditional for the departmental supervisor or his clerk to keep themselves informed about the starting date and progress of each order by means of various dispatching displays.

14.4. MEANING OF FOLLOW UP

After the dispatching function is completed, processing of various operations has been authorized to begin in time as planned by scheduling department; the follow up is to check the progress of the order undertaken as it is being produced from the first operation until the order is converted into final product. Thus it regulates the progress of material and parts through the production processes.

Follow up is checking the manufacturing activities systematically so that production may be carried out according to plan. It is the measurement of output against plan, analysis of the performance for shortcomings if any and following up the management in order to apply corrective action to prevent excessive shortfall.

Thus Progress Reporting is the function by which one can give an early warning when the actual production deviates from planned production thus making it possible to apply corrective action.

Follow up is the most important part of production control. This step is to ascertain from time to time that the production operations are going on according to the plan. The expeditor or chaser is meant for observing that anything overlooked or not properly executed is set right.

This ensures proper coordination of production activities and plans in order to take corrective action if necessary. Follow up functioning checks and measure the effectiveness of previous production control

functions like routing, scheduling and dispatching. Expediting is a special form of follow up or progress reporting.

14.4.1. EXPEDITORS ARE USED

a.) To help to eliminate particular difficulties which are throwing production of the schedule.

b.) To speed up the processing of certain orders.

In short the purpose of active functions of dispatching and expediting are :

(i) To release the production orders at the appropriate time and provide the flow of necessary information.

(ii) To record the flow of materials and tools and make adjustment if needed.

(iii) To record progress of production activities and make necessary adjustments. (iv) To compare and record amount of work in process with schedule.

(v) To record the amount of faulty work and rejections, issue orders for the production of replacements.

(vi) To record the machine and manpower idleness and investigate the reasons for it.

(viii) To record the breakdowns, held up or stoppage of production activities and classify them according to:

- Lack of instructions and blue prints etc.
- Lack of input materials and components.
- Work held up due to stoppage at previous workstations.
- Equipment break down.
- Non availability of manpower

14.5. FUNCTIONS AND PURPOSE OF FOLLOW UP

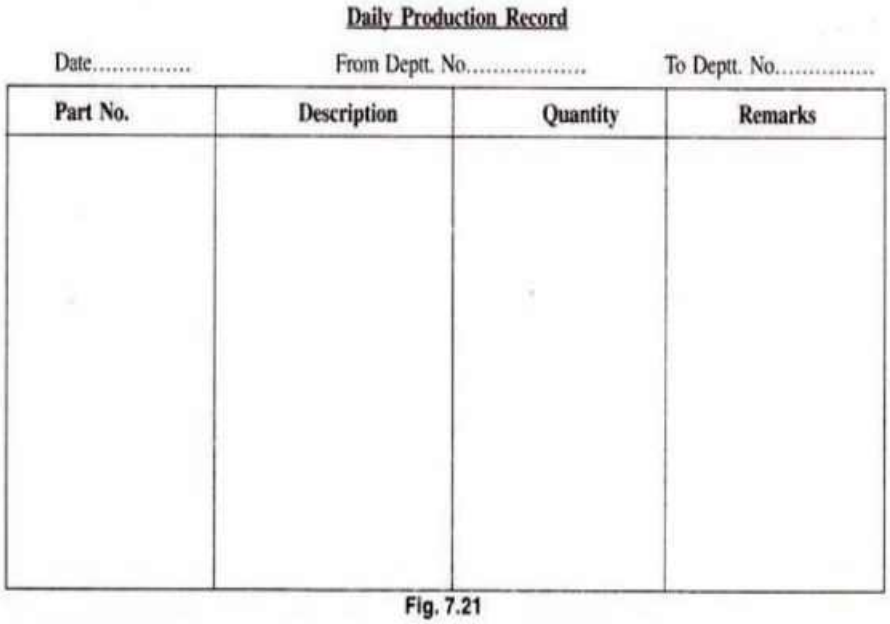
Its main function is to bring up together all the variables of production activities and thus to show progress or boost production. It is the duty of follow up people to see whether the production is being performed according to the schedule and to provide feedback on the production data.

Follow up is done for the following purposes:

(i) ***Follow Up for Materials*** : Logically it is the duty of the purchase department to ensure that the requisitioned material should reach

the requisitioned on or before the date of delivery to meet the production schedule promises. But in case of very important orders which must be met in time, the follow up section of the production control department, takes steps for collection of the materials. In such cases follow up is accomplished by filing one copy of the requisition slip in a daily follow up file according to the due date the material is to be received.

(ii) ***Follow Up of Work-in-Progress*** : In case of serialized production, it consists of check on the required materials for specific process and recording the production output of the production department to see whether it is in accordance with schedule. In this case follow up is very simple and can be trusted to daily production records as shown in figure :



Daily Production Record

Date..... From Deptt. No..... To Deptt. No.....

Part No.	Description	Quantity	Remarks

Fig. 7.21

Figure 14.2 : Daily Production Records

In order to meet schedule promises, some priority may be given to the late jobs. In case of job order manufacture, where the different products are produced at the same time, the sequence of orders may be changed in order to meet certain specific situations.

The section in charge or production engineer should be advised by the follow-up man regarding the best sequence in which orders should be taken up in order to provide the completion of the assembly at proper time and place. A time record of job or order showing the start and completion time, number of pieces produced and rejection is made.

(iii) ***Follow Up for Assembly and Erection***:In such situations one follow up man is given the entire responsibility. The various parts

and components being manufactured at various work stations may be temporarily stored at those very places so that the follow up man shall release them when the rest of the component parts forming the assembly are ready for final assembly purposes. In case of very complex and large equipment/products, the work of installation erection and servicing is done at purchaser's place. The requirement will be that the follow up man should be well acquainted with the engineering details, trouble shooting and servicing of the equipment/machine at the consumer's plant.

Follow up or Progress Reporting can do following tasks:

(i) Recording of actual production.

(ii) Compare the actual production with the planned production.

(iii) Can measure the production variability.

(iv) Can report the excessive variance to the production planning department for corrective action.

14.6. APPLICATION OF COMPUTER IN PRODUCTION PLANNING & CONTROL

Over the last 40 years, the role of computers in the production planning process has changed dramatically. In the 1970's, a calculator was considered a high-priced luxury item, and business mainframe programs were stored on cards. Today, every production planner has a personal computer with more processing capability than the mainframes of the past. Advances in computer hardware and software have enabled production planning processes to operate more efficiently and effectively than ever before.

Some of the areas where computers are used in business and industry are as follows:

[a] Inventory Control,

[b] Production Planning,

[c] Budgeting and Variance Analysis,

[d] Plant Capacity Utilization,

[e] Quality Control,

[f] Market Research,

[g] Purchase Accounting,

[h] Sales Accounting,

[i] Payroll Accounting,

[j] Information Management, and so.

Role of Computer :

With the expansion of business activities, the volume of business transactions has increased. The manual method of maintaining books of accounts is found to be unmanageable and gradually computers have replaced the manual method of accounting. And finally the database technology has revolutionized the accounting departments of business organizations. Computer is an electronic device that can perform a variety of operations in accordance with a set of instructions called program. It is fast electronic data processing machine, which can provide solutions to all complicated situations. It accepts data from the user, converts the data into information, and provides the desired results.

14.7. SUMMARY

- Dispatching is the routine of setting productive activities in motion through the release of orders and necessary instructions according to pre-planned times and sequence of operations embodied in route sheets and loading schedules.
- In the decentralized dispatching, the manufacturing orders are issued in blanket way to the Engineer/Foreman/Supervisor. He must then determine the relative sequence in which these orders will be taken up within the department.
- Decentralized dispatching minimizes the duplication of postings and elaborate reporting etc. while centralized dispatching is applicable forcontinuous manufacturing system that involves a single standardized product and no assembly, dispatching requires that the concerned shops be informed about the decided rate of production.
- Follow up bring up together all the variables of production activities and thus to show progress or boost production.
- The database technology has revolutionized the accounting departments of business organizations where a variety of operations are performed in accordance with a set of instructions called program. It is fast electronic data processing machine, which can provide solutions to all complicated situations. It accepts data from the user, converts the data into information, and provides the desired results.

14.8. SELF –ASSESSMENT QUESTIONS

Q1. What is dispatching? What are the functions of Dispatching?

Q2. How does dispatching helps in minimizing the duplication of postings in the manufacturing system.

Q3. What is the purpose of follow up done post the dispatching function?

Q4. What is the role of computers in Production planning and control?

Q5. Enlist the areas where computers are used in the Business and Industry.

14.9. SUGGESTED BOOKS/ REFERENCES

1. Chary S.N.: Production and Operations Management, McGraw Hill Education
2. Mahajan M.: Industrial Engineering and Production Management, DhanpatRai& Co.

Uttar Pradesh Rajarshi Tandon Open University

Master of Business Administration

MBA-3.34

Production, Planning and Control

BLOCK

5

INVENTORY CONTROL AND RECENT TRENDS IN PPC

UNIT-15

Inventory Control

UNIT-16

Ordering Procedures of Inventory

UNIT-17

Computer Integrated Production Planning System

परिशिष्ट–4

आन्तरिक कवर–दो का प्ररूप

Format of the II Inner Covers

लेखक Dr. Ekta Verma, Asst. Professor MONIRBA University of Allahabad, Prayagraj

सम्पादक Prof. J.N. Bhargawa, MONIRBA, University of Allahabad, Prayagraj.

परिमापक

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UNIT-15 INVENTORY CONTROL

Unit Structure

15.0 Unit Objectives

15.1 Introduction

15.2 Categories of Inventory

15.3 Inventory cost

15.4 Purpose of holding stock

15.5 Effect of demand on Inventories

15.6 Dependency of Material Requirement planning on demand

15.7 Inventory control

15.8 Summary

15.9 Self-Assessment Questions

15.10 Suggested Books/ References

15.0. UNIT OBJECTIVES

In this unit, a brief layout of inventory control, purpose of holding stock, effect of demand on inventories have been given to provide a clear understanding of the chapter.

15.1. INTRODUCTION

The amount of material, a company has in stock at a specific time is known as inventory or in terms of money it can be defined as the total capital investment over all the materials stocked in the company at any specific time. Inventory may be in the form of, raw material inventory, in process inventory, finished goods inventory, spare parts inventory, office stationary etc.

As a lot of money is engaged in the inventories along with their high carrying costs, companies cannot afford to have any money tied in excess inventories. Any excessive investment in inventories may prove to be a serious drag on the successful working of an organization. Thus there is a need to manage our inventories more effectively to free the excessive amount of capital engaged in the materials.

Why Inventories?

Inventories are needed because demand and supply cannot be matched for physical and economic reasons. There are several other reasons for carrying inventories in any organization:

- To safe guard against the uncertainties in price fluctuations, supply conditions, demand conditions, lead times, transport contingencies etc.
- To reduce machine idle times by providing enough in-process inventories at appropriate locations.
- To take advantages of quantity discounts, economy of scale in transportation etc.
- To decouple operations i.e. to make one operation's supply independent of another's supply. This helps in minimizing the impact of break downs, shortages etc. on the performance of the downstream operations. Moreover operations can be scheduled independent of each other if operations are decoupled.
- To reduce the material handling cost of semi-finished products by moving them in large quantities between operations.
- To reduce clerical cost associated with order preparation, order procurement etc.

15.2. CATEGORIES OF INVENTORY

The first categorical division of inventory is based on the *source of demand.* There are essentially two ways to categorize inventory based on the source of demand:

- ***Independent demand inventory:*** The source of demand for this type of inventory is typically from sources outside the company itself, usually emanating from an external customer. It is called independent since the demand for it is essentially independent of any internal actions of the firm. In many cases these items are the end items of production, often a "sellable" finished good.
- ***Dependent demand inventory:*** The source of dependent demand inventory is directly dependent on internal decisions, primarily on the decision of how many of which product to produce at what time. It should be noticed that some may think this is still dependent on customers, but in fact many firms can decide to produce at far different times and at different rates than what represents the external customer demand. This goes back to the concept of inventory as stored capacity. An example may help clarify the difference. Suppose the company makes chairs. The demand for the finished chairs comes from external customers, and is independent demand. On the other hand, the demand for the seats, backs, and legs is dependent on the internal decision of how many chairs to make and when to make them. The distinction

between independent and dependent inventory is a very important distinction for production planning and control. The approaches and systems used to plan and control independent inventory are very different from those used for dependent inventory, and result in systems that are also often quite different from each other. Even the approach to capture the demand of each type is different. Independent demand is usually forecasted and then captured through sales order entry. Dependent demand, on the other hand, can be calculated based on the schedule of what to make and when.

The second categorical division is based on *the position of the inventory in the process.* The four general categories include:

- **Raw materials** represent inventory that has been purchased for use in the production process, but have had no value added by the company's production process.
- **Work in process *(WIP)*** represent inventory that has had some value added, but still has additional processing to be completed before it can be used to meet customer demand.
- **Finished goods** represent inventory that has completed all the processing from the firm. It is generally ready to be used to meet customer demand, with the possible exception of packaging.
- **Maintenance, repair, and operations (MRO)** inventory is material used to support the company's business and production processes, but typically will never be directly sold to a customer. It is made up of spare parts, machine oil, cleaning supplies, office supplies, and so forth.

The third and final categorical division is the *junction or use of inventory in the process.* The most common categories in this area include:

- **Transit inventory** is inventory in motion from one activity to another. Inventory in the transportation system is the most common form.
- **Cycle inventory** is inventory that exists because for any time period the rate of replenishment exceeds the demand-a situation often caused because of order costs, setup costs, or packaging considerations. An example may clarify. Suppose an office supply store sells approximately 10 pens of a certain style per day, on average. When they order a replenishment supply from their distributor, the pens can only be shipped in packages of 500. When a shipment arrives, there are 500 (assuming that none of the old supply remain) in inventory. The next day there will be approximately 490, the day after that 480, and so forth. The inventory left from the shipment of 500 day after day for the next 50 days is called cycle inventory.
- **Buffer inventory** is also called safety stock, and exists "just in case." There are many situations that can occur in a firm that can

disrupt the normal flow of work in the operation. Workers can fail to come to work, suppliers can be late with shipments or ship the wrong product, quality problems can occur, machines can break down, and so forth. Inventory that is maintained explicitly to protect the organization just in case one or more of these problems occur is called buffer inventory or safety stock.

- **Anticipation inventory** is inventory built up on purpose in anticipation of some demand in excess of the usual production output. The two most common uses for this are to accommodate seasonal demand or marketing promotions. Products that have highly seasonal demand will often have inventory built up during the periods of low demand in order to meet customer demand during the peak season. Also, if the marketing group is planning a special promotion or a sale of a product, the demand can (if the program is successful) be expected to rise significantly. As some firms have found out the hard way, planning a promotion without adequate product to meet the demand generated can be quite damaging to customer relations.
- **Decoupling inventory** is inventory that is purposely placed between operations to allow them to operate independently of one another. Again, an example may illustrate this function the best. Suppose we have two operations, A and B. Operation B uses the output from operation A. The capacity of A is 90 per hour while the capacity of B is 100 per hour (see Figure 15.1).

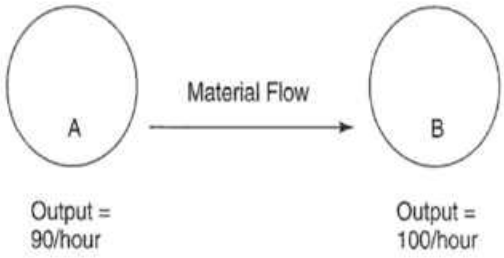


Figure 15.1 : Linked Operations with Different Production Rates

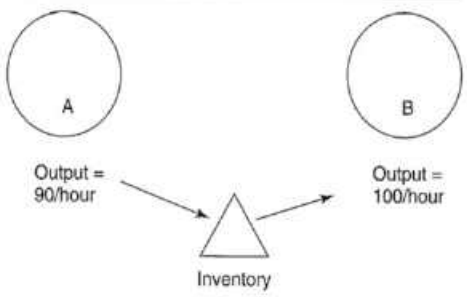


Figure 15.2 : Operations A and B Decoupled

The problem with this situation occurs when the operators and the processes are measured by the typical approach used for many facilities, efficiency and utilization. In this case the operator for operation B is waiting for the output from operation A 10% of the time, impacting the efficiency of the operation negatively - and the poor efficiency is totally out of their control. If the facility wants to maximize efficiency of all operations, they may want to alter the situation to look like the following (Figure 15.2).

In this second situation illustrated by Figure 15.2, the inventory between the operations (decoupling inventory) serves to allow each operation to operate more independent of each other. Operation A can produce without worrying about B, by merely putting the output into inventory. Operation B can be run efficiently by using the inventory rather than waiting for the output from A. Operation A may need to work more hours than B, since B uses the inventory faster than A can replace it, but they can still be more independent of each other.

15.3. INVENTORY COSTS

In order to control inventories appropriately, one has to consider all cost elements that are associated with the inventories. There are four such cost elements, which do affect cost of inventory.

i. ***Carrying costs*** : This represents the cost of maintaining inventories in the plant. It includes the cost of insurance, security, warehouse rent, taxes, interest on capital engaged, spoilage, breakage etc.

ii. ***Stock out costs*** : This represents the cost of loss of demand due to shortage in supplies.

iii. ***Unit cost*** : it is usually the purchase price of the item under consideration. If unit cost is related with the purchase quantity, it is called as discount price.

iv. ***Procurement costs*** : This includes the cost of order preparation, tender placement, cost of postages, telephone costs, receiving costs, set up cost, cost of loss of profit, loss of customer, loss of goodwill, penalty etc.

15.4. PURPOSE OF HOLDING STOCK

1. **To maintain independence of operations.** A supply of materials at a work center allows that center flexibility in operation. For example, because there are costs for making each new production setup, this inventory allows management to reduce the number of setups.

   Independence of workstations is desirable on assembly lines as well. The time that it takes to do identical operations will naturally vary from one unit to the next.

Therefore, it is desirable to have a cushion of several parts within the workstation so that shorter performance times can compensate for longer performance times. This way the average output can be fairly stable.

2. **To meet variation in product demand.** If the demand for the product is known precisely, it may be possible to produce the product to exactly meet the demand.

   Usually, however, demand is not completely known, and a safety or buffer stock must be maintained to absorb variation.

3. **To allow flexibility in production scheduling.** A stock of inventory relieves the pressure on the production system to get the goods out. This causes longer lead times, which permit production planning for smoother flow and lower cost operation through larger lot size production. High setup costs, for example, favour producing a larger number of units once the setup has been made.

4. **To provide a safeguard for variation in raw material delivery time.** When material in ordered from a vendor, delays can occur for a variety of reasons: a normal variation in shipping time, a shortage of material at the vendor's plant causing backlogs, an unexpected strike at the vendor's plant or at one of the shipping companies, a lost order, or a shipment of incorrect or defective material.

5. **To take advantage of economic purchase order size.** There are costs to place an order: labour, phone calls, typing, postage, and so on. Therefore, the larger each order is, the fewer the orders that need be written. Also, shipping costs favour larger orders – the larger the shipment, the lower per unit cost.

15.5. EFFECT OF DEMAND ON INVENTORIES

Demand generates forecasts based on sales history, currently scheduled orders, scheduled marketing activities and customer information. Ideally, demand management works collaboratively and interactively both internally across the firm's functional components and externally with supply chain partners to develop a common and consistent forecast for each item period, location and item.

The forecast must also incorporate feedback from customers to integrate the influence of combined demand generation activities such as advertising and promotion. Practically, demand management and forecasting are closely related, and forecasting is an extensive topic in itself.

Demand forecasting is a critical tool in the management toolbox. Because the mostly widely cited reasons for forecasting include:

- Increase customer satisfaction
- Reduce stock out
- Scheduling production more efficiently
- Lowering safety stock requirements
- Reducing product obsolescence costs
- Managing shipping better
- Improving pricing and promotion management
- Making more informed pricing decisions

And above reasons are essential to management decision making.

The forecasting time frames are:

(1) Long term forecasts, usually cover more than three years and are used for long range planning and strategic issues.

(2) Midrange forecasts usually range from one to three years and address budgeting issues and sales plans.

(3) Short term forecasts are most important for the operational logistics planning process. They project demand into the next several months and, in some cases, more than a year ahead.

15.6. DEPENDENCY OF MATERIAL REQUIREMENT PLANNING ON DEMAND

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

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

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

also not necessary to stock up items that are related to the dependent demand.

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

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

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

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

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

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

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

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

Earlier it was not done because of huge data processing costs and the time taken for computation. Now, with the availability of computer

facilities at a cheaper rate, computation costs are declining and inventory costs are rising. Hence, it has become easier to justify time phased materials planning systems which ensure tight operational control. It is rapid, flexible and responsive to changes in the requirements.

15.7. INVENTORY CONTROL

Methods for properly controlling inventory are often ignored or given little exposure in many operations management books, yet remain a critical issue for many modern planning and control systems. These modern planning and control systems (such as ERP systems) are highly integrated computer-based systems that can be extremely effective and provide great benefits for a company using them properly. Unfortunately, they are also extremely sensitive to the accuracy and timeliness of the data used to generate their information. Far too many companies achieve far less benefit than is possible due to basic control problems, and inventory control is one of the most critical.

What level of accuracy is necessary? Clearly that is a matter of opinion, but most agree that an on-going accuracy level in the very high 90 percentile range is required in order to maintain confidence in the accuracy of the information from modern planning and control systems. This is also dependent, of course, on the basic business policies of the firm, but if the accuracy levels are allowed to decline much below this high level, people will increasingly become sceptical regarding the information being generated by the system. Two clear symptoms of inaccurate information are growth in inventory levels (as people bring more in "just in case" the records are incorrect) and a corresponding growth in expediting activity as people are caught with inventory shortages when they thought adequate inventory existed for their need.

15.7.1. THE RIGHT PERSPECTIVE

The first issue that should be clearly understood is how to measure the accuracy level. Some take the accounting perspective resulting from the annual physical inventory. The following example illustrates the potential problem with that perspective. Suppose a firm has four items in their inventory - A, B, C, and D. The information they have on the item cost of those items and the number in inventory is given as follows:

Item	*Cost*	*Quantity*
A	$2	10
B	$5	4
C	$1	22
D	$3	8

The total value of the inventory is $86, found by taking [10($2) + 4($5) + 22($1) + 8($3)]. Now, suppose a physical inventory is taken. The actual count shows the following:

RECORD

Item	*Cost*	*Quantity*	*Actual Count*
A	$2	10	15
B	$5	4	0
C	$1	22	17
D	$3	8	13

The total value of the actual inventory based on the count is $86, again found by [15($2) + 0($5) + 17($1) + 13($3)]. From a pure financial perspective the inventory accuracy was 100%, in that the records showed $86 in inventory and the actual count confirmed that. Unfortunately, from a planning and control perspective the actual record accuracy was 0%, in that not one single record was correct in the quantity of items. If someone claims the inventory records are correct, they should try to convince the person who counted on using the four units of item B for an immediate customer requirement! The message here is clear-from the perspective of planning and control, only the actual item count should be used to determine record accuracy. In fact, item count alone is NOT sufficient. In addition, the locations of the items are just as important.

Knowing a certain quantity of inventory is available does little good if someone does not know where the inventory is located.

15.7.2. LOCATION APPROACHES FOR STOCKROOMS AND WAREHOUSES

There are three basic approaches for locating items in a stockroom or warehouse, each with certain advantages and disadvantages. The three are home base, random, and zoned random.

Home base implies that each item has its own distinctive location, and that the item is always stored in just that location. *The location is, therefore, dedicated to that specific item.* The advantage of this approach is that the location is always known and therefore easy to find. The disadvantage is one of space. The location needs to be kept open for that item even if there are currently none in stock. The problem gets much worse if new items are added to the system as products are added or engineering changes impact existing products. The number of locations will grow as new items are added, making an ever growing demand for space. Clearly this approach works best when the items to be kept in inventory are quite stable in number and design. Random is just the opposite approach. Whenever a new item is entered into the stockroom or warehouse, it is placed in whatever location is available (open space)

anywhere in the storage area. This approach will generally maximize the efficient use of space, but there is one major disadvantage namely, the location must be carefully noted and accurately placed into the location database. Any item that has any mistake in noting or recording the location may become almost completely lost, forcing a massive search of the entire storage area. This system is most commonly used where products are rapidly changing in design, making the home base approach far less practical.

Zoned random is a "hybrid" approach that attempts to combine the best of both approaches, and is generally applicable in all but the most extreme situations. The concept here is to identify a zone where items belonging to some defined class of goods (often commodity based) will all be stored. For example, there may be one zone for fasteners, another for electronic components, and so forth. *Within the zone, the items may be stored in a random fashion.* The advantage is as follows - the random storage of parts within the zone allows for efficient use of space, while the zone concept allows for easier investigation should the location be in error on the system. If a location is incorrect, only the zone needs to be checked - not the entire stockroom.

15.7.3. MAINTAINING INVENTORY DATA ACCURACY

One area of inventory control that is often underappreciated and sometimes even overlooked is that of keeping the inventory database accurate and timely. People will often either assume that the information in the system is accurate or else fail to realize how much poor accuracy will adversely impact the entire planning system. This section describes the importance of such data and some of the more common methods used to obtain and maintain the accuracy level needed for effective planning.

The risky approach is that some companies regard inventory control and stockroom or warehouse work as a mundane activity requiring little skill or responsibility. In these environments the workers in the inventory control area are often low paid and given little training or education. Often the workers in these companies view the inventory job as a "foot in the door," allowing them to later move into a "better" job as a machine operator, assembly worker, or some other job requiring more skill and better pay.

Whether that type of approach to inventory control is the cause or not, the fact remains that the costs of having poor inventory records will typically far exceed that of correcting the records and keeping them correct. Unfortunately, many companies will not realize the costs of poor records and attribute the problems to other causes. Some of the symptoms of poor inventory records include :

- ***Excessively high inventory levels :*** The more that people using the records to make decisions and plans suspect the accuracy of those records, the more they will have the tendency to request excessive

amounts of inventory "just in case" the records are incorrect. One question commonly asked with respect to the issue of too much inventory is how can one tell that the level of inventory is excessively high? The starting point to answer that question begins with an analysis of the inventory turns. Turns are commonly calculated by taking the cost of goods sold for the year (from the income statement) and dividing it by the dollar value of the inventory on the books from the balance sheet. This figure can then be converted into the amount of inventory available in a time basis. For example, if the inventory turns are 3, that implies 4 months of inventory (12 months divided by 3 turns). That figure needs to be compared with what a reasonable level of inventory should be. That number can be calculated by looking at the routing information for a typical product. Add the total of all the times (processing, setup, move, etc.) and then consider the run time as a multiple of the lot size. Add in a reasonable allowance for queue time and other factors as appropriate (inspection and kitting, for example). Then compare that figure with the inventory turn figure. As an example, one company recently wanted to reduce their inventory so the inventory turns would change from 4 turns to 6 turns. The question was raised, "Is 6 turns reasonable? That represents only two months' worth of inventory." After an examination of the routing for their major product, it was noticed that the total setup and processing time was only 4 hours! Even with a very liberal allotment for non-value-added activities, the 2 months of inventory turns represented by the 6 turns appeared to be far too much. This issue of "too much" is, of course, also related to business policies concerning inventory levels, but at least the analysis suggests that such policies should be reviewed to determine if they are reasonable. If so, then the focus for improvement should be on the causes of such levels of inventory.

- ***Premium freight shipments :*** These commonly occur when the records indicate that a certain item supplied by an outside supplier is in stock and not in need of replenishment, and then the discovery is made that the stock position is much smaller than indicated. In these cases the firm often needs to place a rush order, and usually has to request shipment by the fastest means possible. The fastest method of shipment is often not the least expensive, causing excessive shipping costs.

- ***Expediting :*** Expediting can occur for both internally produced and supplier products. While it is sometimes done in response to a customer request, it also often occurs when the actual inventory position is much less than indicated on the records. Expediting causes many people to bypass systems, create inefficiency, and in general expend a great deal of extra time and money to try to get the inventory replenished in a time frame much shorter than the usual replenishment time.

- ***Split lots :*** Often a result of expediting, split lots can occur when a normal production run has its setup broken to use the equipment to produce another part in short supply. Often the original setup has to be redone after the expedited run is complete so the rest of the normal production lot can be finished. The activity of setting up equipment twice for a single production run costs the company both time and money.

15.7.4. THE STRUCTURED APPROACH

The first thing that should be understood is that all inventory accuracy is not alike. If you have some inventory that is worth several thousand dollars each, then even missing one unit is serious. On the other hand, a small screw worth $0.005 is not worth bothering with. The process used to establish the relative importance of an item is called ABC inventory distribution. The concept is to separate the inventory based on the annual dollar usage. Annual dollar usage is, of course, the dollar value per item times the average number of items used per year.

There is no hard rule for the separation of A, B, and C items, but the "rule of thumb" that is often used is to list all items in order of highest annual dollar usage to lowest. The top 20% of the items will often represent the A items, those between 20 and 50% will be the B items, and the lowest 50% will be the C items. It is often found, as indicated in the generic distribution graph shown in Figure 5.7 that the A items, while representing only 20% of the total items, may represent from 70 to 80% of the annual dollar investment of the firm. Once the items have been classified, the attention paid to the control of an item will be based on that classification. "A" items, for example, will often be monitored very closely and have the accuracy of the data checked as often as once a month (in some cases more frequently). If the *"A"* items can be easily moved, they are often kept in a locked storage area or tightly controlled in other ways. "C" items, on the other hand, will often have far less control. In some cases they are treated like independent inventory (using a reorder point) even if they are dependent demand items. They will often have a large amount of safety stock, as the inaccuracy of the records has a far greater tolerance. These records are also checked far less often - usually only once a year. The "B" items, as one would suspect, are treated more carefully than "C" items, but not monitored as closely as are the *"A"* items.

There are some cases when a low-cost item may be artificially elevated to an *"A"* classification. Suppose, for example, that a low-cost item has a very long replenishment lead time and there is a very large penalty for a stock out. This may come from the part being a required part for a large assembly and there are no substitutes. Missing the one part can cause delay of a major high value shipment while replenishment is underway, and if that delay is long it could cause serious erosion of customer confidence and loyalty. Under those circumstances the firm may

elect to purposely elevate that item to an *"A"* classification, even though the quantitative analysis would normally classify the item as a "C" item.

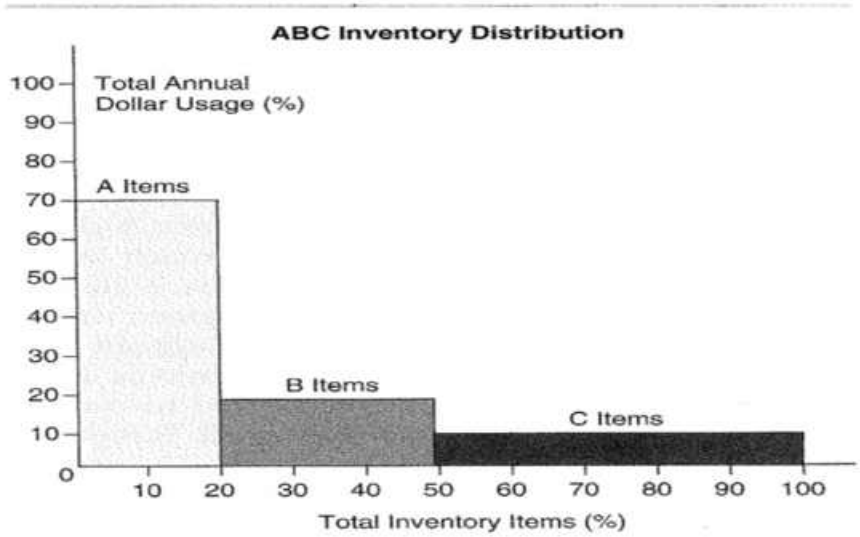


Figure 15.3 : A Sample ABC Distribution

As is suggested by the above discussion, one of the major purposes of the ABC classification is to indicate those items that deserve closer attention and a higher level of inventory accuracy because of the financial implications to the firm of an inaccurate record.

15.7.5. OBTAINING ACCURATE INVENTORY RECORDS

There are basically two methods to check records for accuracy and correct those found to be incorrect. Those methods are a **complete ("wall-to-wall") physical inventory** and **cycle counting.**

"Wall-to-wall" physical inventory: This process involves establishing a fixed time period to physically count all the items in inventory for the entire operation. Often the production processes may need to be suspended for several days while this is being done, especially since the production workers are sometimes called on to assist with the count. This process is often done at least once per year, often in conjunction with the accounting fiscal year cycle. The accounting system will typically require an accurate dollar value of the inventory, as it usually appears as a major asset on the accounting balance sheet of the firm. The problem with this approach goes well beyond the obvious problem of the loss of production while the count proceeds. Counting parts for several hours over several days is tiring and boring, especially for production people not used to doing that type of work. Human fatigue and apathy will often produce new inaccuracies in the count. In addition, so many people handling parts in this manner

increases the risk of damage or dislocating the parts after the count is made. In addition, since this process is typically done only once per year, the inaccuracies will build over time, especially if the transaction system recording the inventory usage and flows has any flaws.

Cycle counting : Cycle counting is often used as a highly preferable alternative to the wall-to-wall physical inventory approach by many companies. As the name implies, this approach is to count each item on a defined cycle throughout the year. Specific individuals are trained and assigned (often as a full-time job) to perform the cycle counts throughout the year. This is often done instead of, not in addition to, the annual physical inventory count. Each day there are certain items identified to cycle count. These items are counted and inaccurate records corrected. Record correction is, however, not the primary purpose of the approach. *The primary purpose of cycle counting is to track down the cause of the incorrect record and fix the process so that the records have a better chance of being maintained correctly between count periods.* Essentially, if an incorrect record is discovered, all transactions for the record since the last time the record was known to be correct are listed. The cycle counters then try to discover which of the transactions caused the accuracy problem and why. The process can then be corrected. Many cycle counters in companies that use the process correctly have to be knowledgeable people that understand the systems and processes of the company. They clearly have to have many skills beyond just their ability to count parts.

The primary purposes of cycle counting are, then, to:

- Identify the causes of record errors
- Correct the conditions in the processes that cause the errors
- Maintain a high level of inventory record accuracy for both count and location
- Provide a correct statement of assets for the accounting system

There are several approaches that can be taken to identify the items that need to be counted during the cycle count on any given day. The more common methods include :

- *The ABC system:* This implies the frequency and the definition of "accurate" will depend on whether the item has been classified as an A, B, or C item as described earlier. There is no hard and fast rule, but most will use something like the following:

Classification	Frequency of count	Accuracy level
A	Once a month or more frequent	1%
B	Every 3 months	5%
C	Once a year	10%

What this shows is the *"A:'* items are counted more often and a much lower tolerance of inaccuracy is acceptable. This is, of course, because of the much higher dollar value of those items. There is sometimes an issue raised as to what to do if the record and the count are different, but still within the accuracy tolerance. For example, suppose the record for a "C" item shows 920 in inventory but the count shows 905. The percentage difference is only 1.6% *(15/920),* which is far less than the 10% allowable accuracy percentage. Should the record be changed to show the 905 or left at 920? Again, approaches differ in practice, but the position of many companies is to leave the record alone since it is within the tolerance level. This is because the cycle count itself may be somewhat off. Sometimes companies will require a double count in the case of an inaccurate record just to confirm that it is the record and not the first count that was in error. While this method provides a good opportunity to obtain the most accurate record, it is costly in both time and money, and is usually not worth the expense, especially for "C" items.

- ***The reorder system :*** This approach is to count items at the time when they are reordered, meaning their inventory is likely at a very low point and therefore much easier and quicker to count.
- ***The receiver system :*** Similar to the reorder point approach, the inventory is likely to be low when new items are received, making the counting process easier.
- ***The zero or negative balance system :*** When the record indicated a zero balance or a negative balance, it would be quite easy to check, since again the inventory should be quite low (if it exists at all). This becomes especially important if the record indicates a large negative balance.
- ***The transaction system :*** Count when a specified number of transactions have occurred. The idea here is if there has to be some "detective" work done to find out the cause of any errors, the detection of the cause will be easier if there are not too many transactions involved.
- ***The zone system :*** If the zone random system of location is used, sometimes a complete zone is targeted for a cycle count. This makes it easy to determine location identification problems.

Cycle count advantages : There are numerous advantages to using an effective cycle count program. They include:

- Operations do not have to be suspended
- The annual physical inventory can be eliminated
- Errors can be more quickly discovered
- The causes of errors can be tracked more effectively and quickly, and
- processes can be corrected more effectively

- Records can be adjusted as necessary throughout the year
- Overall record accuracy generally improves greatly
- Correct statements of assets can be obtained throughout the year - no big year-end inventory "shrinkage" surprises
- Improvement efforts can be concentrated in problem areas
- Specialists (cycle counters) become effective in getting good counts and count procedures and can become effective problem solvers for process problems.

15.8. SUMMARY

- The most important considerations for planning and control of inventory are given by two simple but critical observations. First is that inventory should be considered to be stored capacity, and should be treated as such. The second is that inventory always exists as a symptom of the way the business is designed and managed. It should never be considered a problem, but can be viewed as an extremely valuable asset, can be used to determine how the overall operation is being planned and managed, and can also be used as an on-going measure for the effectiveness of the operational planning and control systems.
- Transit inventory is inventory in motion from one activity to another. Inventory in the transportation system is the most common form.
- Cycle inventory is inventory that exists because for any time period the rate of replenishment exceeds the demand-a situation often caused because of order costs, setup costs, or packaging considerations.
- The concept of demand dependency is important between the reactive and proactive (planning) systems. The demand dependency is the degree to which the demand for the same product is associated with the demand for another item.
- The order point techniques based on Economic order quantity (EOQ) are more suited for items having independent demands because they use past usage of sales data to forecast future demands. But for items which have dependent demands such as lower level components, sub-assemblies, etc., usage data is unrelated to the past demands.
- There are three basic approaches for locating items in a stockroom or warehouse, each home base, random, and zoned random.

15.9. SELF-ASSESSMENT QUESTIONS

1. Define inventory. Discuss various types of inventory costs.
2. Discuss the purpose of holding inventory.
3. Why is it important to maintain the optimal level of inventory?
4. Discuss economic batch quantity with suitable examples.
5. Discuss about the various selective inventory control techniques with their application, areas, advantages and disadvantages.
6. What is the setup cost of manufacture?
7. Explain the role of selective inventory control.

15.10. SUGGESTED BOOKS/ REFERENCES

1. Chary S.N.: Production and Operations Management, Mc Graw Hill Education
2. Mahajan M.: Industrial Engineering and Production Management, Dhanpat Rai & Co.

UNIT-16 ORDERING PROCEDURES OF INVENTORY

Unit Structure

16.0 Unit Objectives

16.1 Order Management

16.2 Order Processing and Order cycle time

16.3 Components of Typical Customer Order Cycle

16.4 Two bin inventory control

16.5 Economic Order Quantity (EOQ)

16.6 ABC Analysis

16.7 Summary

16.8 Self-Assessment Questions

16.9 Suggested Books/ References

16.0. UNIT OBJECTIVES

This unit provides a clear understanding of ordering procedures, two bin systems, ordering cycle system, determination of economic order quantity and economic lot size – ABC Analysis.

16.1. ORDER MANAGEMENT

There are few sources in the literature discussing the details of order management explicitly. Order management is however implied in the work of a number of authors. According to Shapiro et al. (1992), order management is one of the core processes in SCM which deals with ten basic activities which are:

a) order planning

b) order generation

c) cost estimation and pricing

d) order receipt and entry

e) order selection and prioritization

f) scheduling

g) fulfillment

h) billing

i) returns and claims

j) Post sales service.

Order management is described as more of a phase which deals with how firm handle incoming orders. This involves the set of activities that are considered in the period between the time a firm receives an order and the time warehouse is notified to ship the goods to fulfill that order. More importantly, *Coyle et al.* states that those dealing with order management in outbound logistics require timely and accurate information related to each individual order. This is necessary since order management is one of the keys to operational efficiency and customer satisfaction in a Supply chain.

16.2. ORDER PROCESSING AND ORDER CYCLE TIME

Order processing is strictly related to information flows in the system and includes a number of operations. A sales order process normally consists of internal document generation within a firm with the aim to manage sales transaction. Customers may have to request the products by filling out an order form. These orders are transmitted and checked. The availability of the requested items and customer's credit status are then verified. Later on, items are retrieved from the stock (or produced), packed and delivered along with their shipping documentation. Finally, customers have to be kept informed about the status of their orders. Traditionally, order processing has been a very time-consuming activity (up to 70% of the total order-cycle time). Thus, most of the time it has been negative effects on time based performance of SCs. However, in recent years it has benefited greatly from advances in electronics and IT. Bar code scanning allows retailers to rapidly identify the required products and update inventory level records. Laptop computers and modems allow salespeople to check in real time whether a product is available in stock and to enter orders instantaneously. Electronic data interchange (EDI) allows companies to enter orders for industrial goods directly on the seller's computer without any paperwork. 'Order cycle time' term defined as the time between when a customer order, or service request is placed and when the product or service is received by the customer. 'cycle time' is the time required to complete a business process. Here, the 'real work' performed during a business process only corresponds to a small percentage (e.g., three to five percent) of the total elapsed time. The rest of the time is typically employed to other counterproductive, time-consuming activities and events. It is therefore possible to improve cycle time by eliminating and or minimizing these time-consuming activities that exist. This shows the importance that organizations are competing on the basis

of time and performance. It does not only depend on superior cost, quality, delivery and technological performance. However, reducing the time needed to provide the end customer with products or services results in better customer satisfaction. Therefore, companies should find ways to improve their cycle time performance by finding common causes that exist behind it.

16.3. COMPONENTS OF TYPICAL CUSTOMER ORDER CYCLE

The customer order cycle includes all of the elapsed time from the customer's placement of the order to the receipt of the production an acceptable condition and its placement in the customer's inventory. The typical order cycle consists of five main steps. Those components of the order processing which is explained below can be seen in the figure :

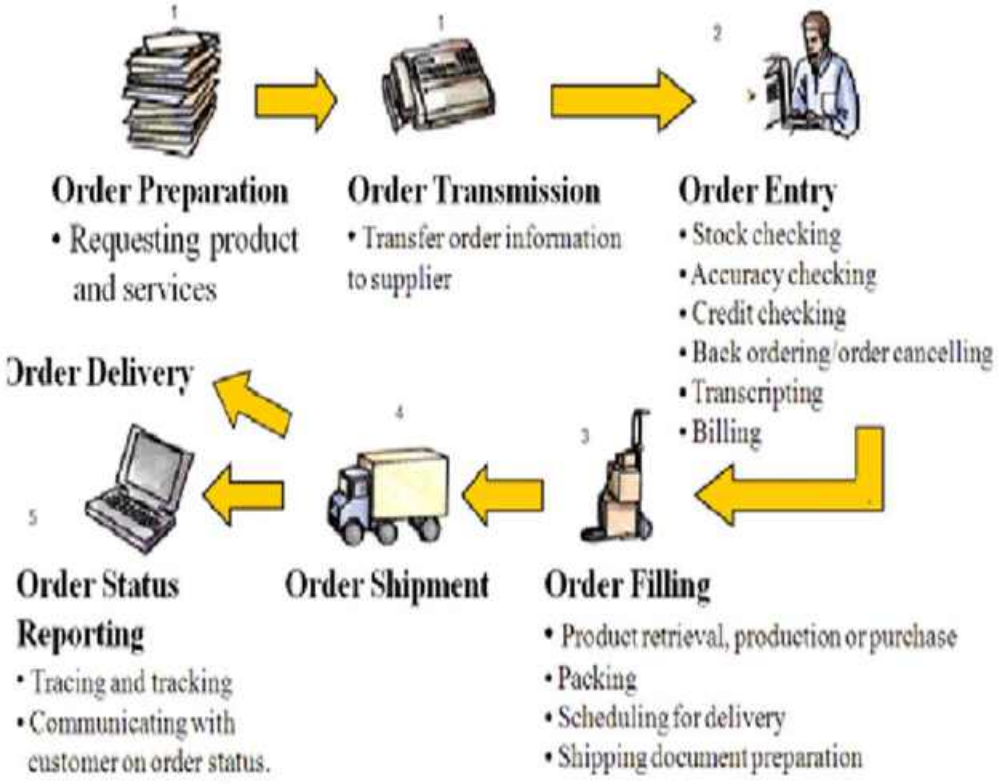


Figure : Components of order processing

Step 1 Order preparation and transmission: 'order preparation' consists of these activities; determining products and services information, filling out an order form, determining stock availability, communicating order information. 'Order transmission' is the series of events that occur

between the times. A customer places or sends an order and the time the seller receives the order. Order transmission can be done in two ways.

a) Manual transmission: Mailing of orders or physical carrying by the sales staff to the order entry point. This option is slow but inexpensive.

b) Electronic transmission: Using telephone, EDI, satellite communication. This method is fast, reliable and accurate, but it allows trade-off analysis.

Step 2 Order processing (order receipt and order entry): Order processing refers to the time from when the seller receives an order until an appropriate location (i.e. warehouse) is authorized to fill the order. First, orders for completeness and accuracy must be checked. Once the order enters into the order processing system, various checks are made to determine if:

a) the customer's credit is satisfactory to accept the order

b) the desired product is available in inventory in the quantities ordered, and the product is scheduled for production if not currently in inventory.

Order form data are utilized for sales records, such as credit status reports, billing schedules, and manufacturing/purchasing schedules. These have to be routed to all departments. The sequence must be so determined that the flow of information is expedited and it is ensured that documentation takes place in all relevant departments. Customers place orders with a customer service representative. After checking credit status, preparing back order or order cancelling documentation must be done. If these activities are performed manually, a great amount of time may be required, which can slowdown (i.e., lengthen) the order cycle. Also customer in placing an order would need an acknowledgement and expected date of delivery. This can be traced by 'status reporting'.

Step 3 Order filling (order picking and packing): Generally, this step includes dispatch of goods, invoicing, shipping and, documentation). After checking credit, prices and etc., the order must to be transmitted to warehouse for execution. The longer is the delay in executing the order, the larger is the possibility that customer will cancel/amend the order. Explicit dispatch instructions to be issued to warehouse and customer should be informed about the status of the order. After receipt of order, the warehouse manager have to order for transport, simultaneously preparing the documents for dispatch for the purpose of accountant of stocks, billing and advice to the customer, billing of transportation and intimation to all concerned including marketing, production, finance, purchase etc. to fulfill the requirements of an integrated system. An expeditious order processing is required. Often represents the best opportunity to improve the effectiveness and efficiency of an order cycle.

Step 4 Order delivery (shipment): Order delivery is the time from when a carrier picks up the shipment until it is received by the customer. As just-in-time delivery has become increasingly commonplace and customer demands continue to tighten, the importance of fast, reliable delivery performance cannot be overstated. This is particularly true for organizations competing internationally, where the complexity of the supply chain must be managed within a global network. The delivery performance is a key indicator for the level of performance a company is able to provide correct and in-time deliveries to its customers. It is a quantitative measure to benchmark an organization against, when it comes to translate customer-relationship related thinking into operational context within logistics and supply-chain related thinking. Depending on business requirements several companies (à industry dependence) need to calculate and monitor the quantity which is delivered in-time at different dates (SAP, online).

Step 5 Order status reporting: This step mainly considers tracing and tracking the order throughout the entire order cycle. This step consists of communication with the customer as to where the order may be in the order cycle and when it may be delivered.

16.4. TWO BIN INVENTORY CONTROL

Two-bin inventory control involves the storage of goods in two bins, one of which contains working stock and the other containing reserve stock. The amount of inventory kept in the reserve stock bin equals the amount the company expects to use during the ordering lead time associated with that item. To use this system, reorder goods as soon as the working stock bin is empty, and replacement parts should arrive before the reserve stock bin is empty. It is possible to fine-tune the inventory investment by altering the amount of goods kept in the reserve stock bin. The calculation for the amount of inventory to keep in the reserve stock bin is:

(Daily usage rate × Lead time) + Safety stock = Reserve bin quantity

For example, a company experiences weekly usage of 500 units of a purple cell battery, so the daily usage rate is 100 units. The lead time for the battery is three days. The reserve storage bin should contain at least 300 batteries, to cover expected usage during the three-day lead time. In addition, the company assumes that usage levels can vary by as much as 25% from the average usage rate. Consequently, 75 additional batteries are kept in the reserve storage bin. This is calculated as 300 reserve units × 25% safety stock allowance. Thus, the total reserve stock is 375 units.

Two-bin inventory control is commonly used for low-value items that can be purchased and stored in bulk, and for which stocks are maintained in the production area, rather than the warehouse. More

expensive inventory items are controlled with a perpetual inventory system.

Example: Company A is a small manufacturer that goes through various types of nuts and bolts to piece together its products. Fasteners are among the many items it orders in from outside suppliers. It uses roughly 800 of them per week, or 160 per day, with a lead time — the period between the beginning and completion of a production process — of three days.

According to the first calculation above, company A's reserve bin should stock at least 480 fasteners. However, management is also aware that usage levels can sometimes fluctuate by as much as 15%, so as a precautionary measure chooses to add some more fasteners to its reserve storage bin. This safety stock could come in handy if demand picks up and production rates increase, as they have in the past.

16.5. ECONOMIC ORDER QUANTITY (EOQ)

Economic order quantity (EOQ) is the ideal order quantity a company should purchase for its inventory given a set cost of production, a certain demand rate, and other variables. This is done to minimize inventory holding costs and order-related costs.

The equation for EOQ also takes into account inventory holding costs such as storage, ordering costs and shortage costs. This production-scheduling model was developed in 1913 by Ford W. Harris and has been refined over time. The formula assumes that demand, ordering, and holding costs all remain constant.

The Formula for Economic Order Quantity is:

$$EOQ = \sqrt{\frac{2 \times D \times S}{H}}$$

Where: Q = EOQ units

D = Demand in units (typically on an annual basis)

S = Order cost (per purchase order)

H=Holding costs (per unit, per year)

The goal of the EOQ formula is to identify the optimal number of product units to order so that a company can minimize its costs related to buying, taking delivery of and storing the units. The economic order quantity (EOQ) formula can be modified to determine different production levels or order interval lengths, and corporations with large supply chains and

high variable costs use an algorithm in their computer software to determine EOQ.

EOQ is an important cash flow tool for management to minimize the cost of inventory and the amount of cash tied up in the inventory balance. For many companies, inventory is the largest asset owned by the company, and these businesses must carry sufficient inventory to meet the needs of customers. If EOQ can help minimize the level of inventory, the cash savings can be used for some other business purpose or investment.

The EOQ formula can be used to calculate a company's inventory reorder point, which is a specific level of inventory that triggers the need to place an order for more units. By determining a reorder point, the business avoids running out of inventory and is able to fill all customer orders. If the company runs out of inventory, there is a shortage cost, which is the revenue, lost because the company does not fill an order. Having an inventory shortage may also mean the company loses the customer or the client orders less in the future.

EOQ takes into account the timing of reordering, the cost incurred to place an order and costs to store merchandise. If the company is constantly placing small orders to maintain a specific inventory level, the ordering costs are higher, along with the need for additional storage space.

Assume, for example, a retail clothing shop carries a line of men's jeans and the shop sells 1,000 pairs of jeans each year. It costs the company $5 per year to hold a pair of jeans in inventory, and the fixed cost to place an order is $2.

The EOQ formula is the square root of (2 x 1,000 pairs x $2 order cost) / ($5 holding cost) or 28.3 with rounding. The ideal order size to minimize costs and meet customer demand is slightly more than 28 pairs of jeans.

16.5.1. LIMITATIONS OF USING EOQ

The EOQ formula inputs make an assumption that consumer demand is constant. The calculation also assumes that both ordering and holding costs remain constant, which makes it difficult or impossible for the formula to account for business events such as changing consumer demand, seasonal changes in inventory costs, lost sales revenue due to inventory shortages, or purchase discounts a company might get for buying inventory in larger quantities.

16.6. ABC ANALYSIS

The application of ABC analysis is on the basis of Annual Consumption value. ABC analysis is based on the principle *Vital few and Trivial many*! Always Better Control, by allocating on selective basis, of the available control efforts in such a way that, the efforts for control of inventory is proportional to its importance. It facilitates management by exception. It is an effective tool for controlling raw materials, components,

and consumable stores inventory. It should be reviewed periodically, so that changes in price and consumption are taken into account. The consumption figures may be annual, half yearly or quarterly but it should be representative. ABC analysis is one where A B and C stand for nothing but expressing the consumption value of commodities in descending order. It may be called *Always Better Control* system for it provides very important directives for controlling the inventory.

The relationship between inventory quantity and inventory value is found very interesting. It has been generalised as below :

Inventory group value	% in quantity	% in consumption
A	5 to 10	75 to 80
	10 to 20	20 to 25
	70 to 80	5 to 10
B		
C		

Percentage for different inventory groups may vary with different industries. Inventory can be analysed into A, B and C groups in the following manner:

1. Calculate annual consumption value for each item.
2. Arrange all items in descending order of its' annual consumption value.
3. Decide the cut-offline either based on quantity or based on consumption value.

16.6.1. BASIC PRINCIPLES OF ABC ANALYSIS

a) Analysis neither depends upon the unit cost of the item nor on the importance of it but only on the annual consumption value of it.

b) The limits for ABC categorisation are uniform but will depend on the size of undertaking, its inventory as well as the number of items controlled.

16.6.2. ADVANTAGES OF ABC ANALYSIS

a. ***Reduction in investment***: under ABC analysis, the materials from group 'A' are purchase in lower quantities as much as possible. With this, the effort to reduce the delivery period is also made. These in turn help to reduce the investment in material.

b. ***Strict control***: under ABC analysis, strict control can be exercised to the materials in group 'A' that have higher value.

c. ***Minimum storage cost***: since, the ,material from group 'A' are purchase in lower quantities as much as possible, it reduce the storage cost as well.

d. ***Saving in time***: since a signification effort is made for management of the material from group 'A', it helps to save time as well.

e. ***Economy***: this method is economical, since equal time and labour is not needed for all types of materials.

16.6.3. DISADVANTAGE OF ABC ANALYSIS

- ABC analysis will not be effective if the materials are not classified into the groups properly.
- It is not suitable for the organization where the costs of materials do not very significantly.
- There is no any scientific base for the classification of material under ABC analysis.
- The classification of the materials into different groups may lead to extra cost. Hence, it may not be suitable for small organization.

16.7. SUMMARY

- Order management is one of the core processes in SCM which deals with the activities such as order planning, order generation, cost estimation and pricing, order receipt and entry, order selection and prioritization, scheduling, fulfillment, billing, returns and claims, Post sales service.
- Order management involves the set of activities that are considered in the period between the time a firm receives an order and the time warehouse is notified to ship the goods to fulfill that order.
- 'Order cycle time' term defined as the time between when a customer order, or service request is placed and when the product

or service is received by the customer. 'cycle time' is the time required to complete a business process.

- Two-bin inventory control involves the storage of goods in two bins, one of which contains working stock and the other containing reserve stock.

- EOQ is an important cash flow tool for management to minimize the cost of inventory and the amount of cash tied up in the inventory balance.

- EOQ takes into account the timing of reordering, the cost incurred to place an order and costs to store merchandise. If the company is constantly placing small orders to maintain a specific inventory level, the ordering costs are higher, along with the need for additional storage space.

- ABC analysis is based on the principle *Vital few and Trivial many*! Always Better Control, by allocating on selective basis, of the available control efforts in such a way that, the efforts for control of inventory is proportional to its importance.

16.8. SELF-ASSESSMENT QUESTIONS

1. Explain the role of selective inventory control.

2. What are the basic assumptions underlying the classical EOQ model. Discuss its limitation.

3. What is ABC analysis? Explain the steps involved in ABC analysis.

4. What is meant by minimum level and ordering level with regard to maintenance of stock? What are the factors that govern the fixing up these levels?

5. What is two bin system. Explain it with the help of suitable example.

6. "Neither over stocking nor under stocking is desirable". Explain this statement and explain the various levels of stock.

7. Explain in detail the components of order Processing.

8. Explain with the help of example two bin inventory control system.

9. Throw light on the basics principles of ABC analysis. Also discuss its advantages and disadvantages.

16.9. SUGGESTED BOOKS/ REFERENCES

1. Chary S.N.: Production and Operations Management, Mc Graw Hill Education

2. Mahajan M.: Industrial Engineering and Production Management, Dhanpat Rai & Co.

UNIT-17 COMPUTER INTEGRATED PRODUCTION PLANNING SYSTEM

Unit Structure

17.0 Unit Objectives

17.1 Introduction

17.2 Material Resource planning (MRP)

17.3 Manufacturing Resource planning (MRP II)

17.4 Enterprise Resource planning (ERP)

17.5 Just in Time (JIT)

17.6 Summary

17.7 Self-Assessment questions

17.8 Suggested Books/ References

17.0. UNIT OBJECTIVE

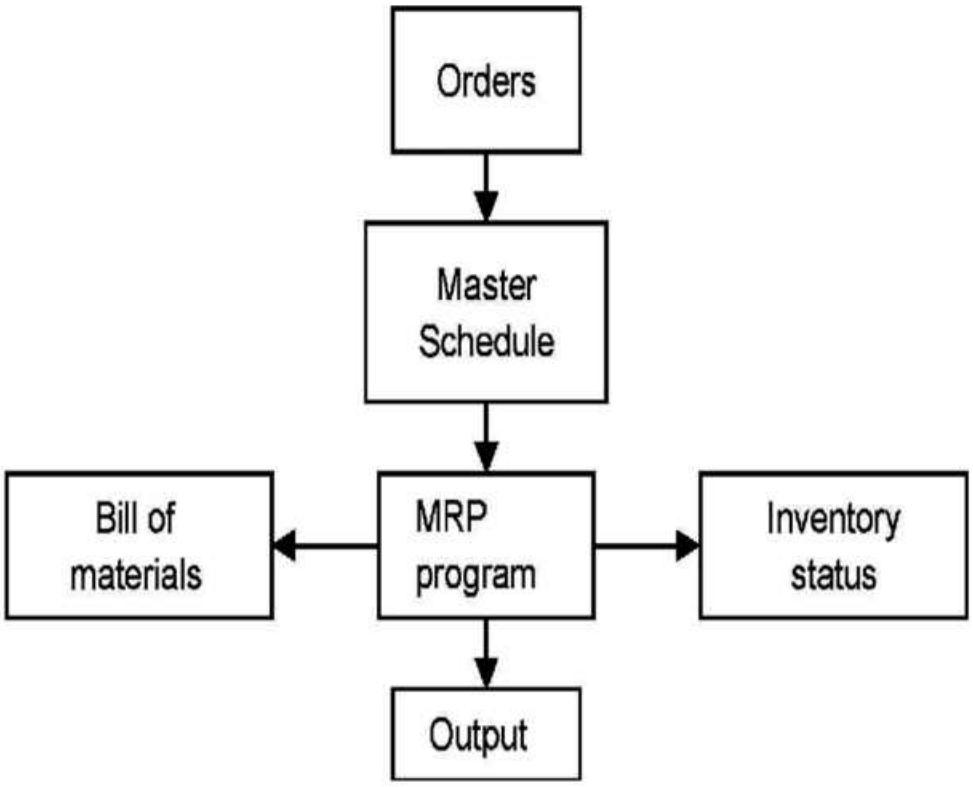
This unit deals with the introduction to computer integrated production planning system, elements of just in time system and fundamentals of MRP II and ERP.

17.1. INTRODUCTION

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

17.2. MATERIAL RESOURCE PLANNING (MRP)

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



17.2.1. SYSTEM COMPONENTS

Material requirements planning system can be represented diagrammatically as follows:

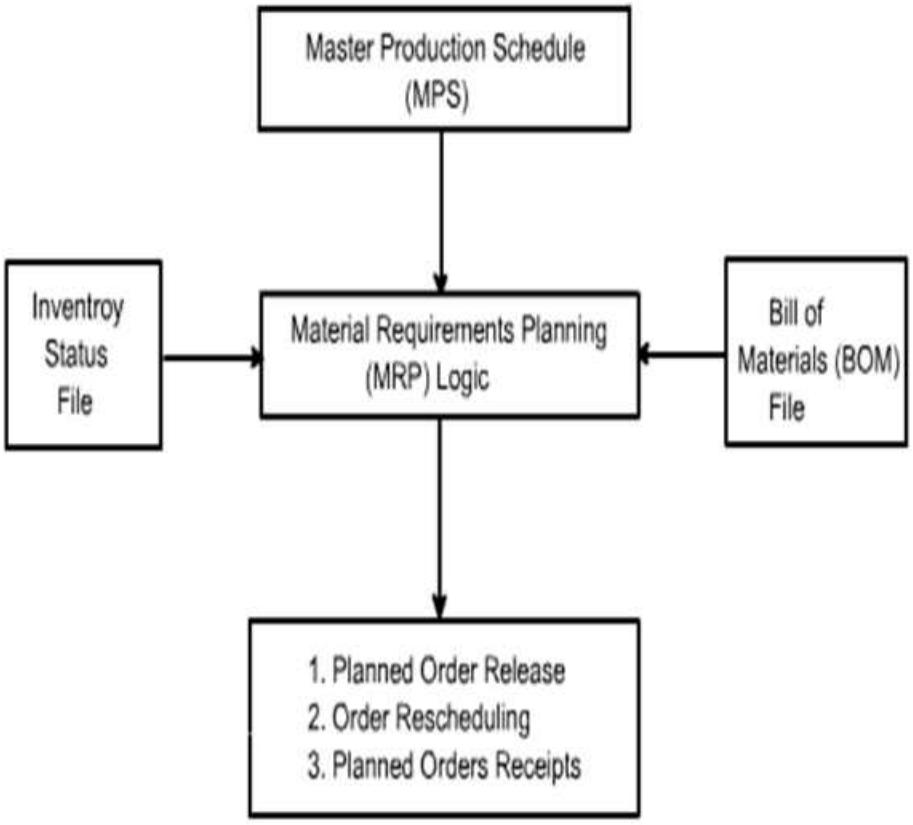


Figure : Components of MRP

Under the MRP system, three major sources of information are necessary, a Master Production Schedule (MPS), a bill of materials file and an inventory status file. These components are discussed below.

Master Production Schedule (MPS)

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

A. Bills of materials

A bill of materials or BOM is a list of the raw materials, sub-assemblies, intermediate assemblies, components, sub-components, parts and the quantities of each needed to manufacture the end product. This information is obtained from product design documents, work flow analysis and other standard

manufacturing and industrial engineering documents. The MRP receives primary information from the BOM i.e. the product structure which shows various components of the product. Each item in the product is given a unique identification number. Taking into consideration the master schedule for the end items, MRP schedules the time phase for the orders for the correct components items in the production structure.

B. Inventory status file

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

17.2.2. OBJECTIVES OF MRP

Following are the objectives of MRP:

- **Inventory reduction :** MRP determines the number of components needed and the time when they are needed to meet the master schedule. It enables the managers to procure the component as it is needed thus avoiding costs of excessive inventory.
- **Reduction in production and delivery lead time :** MRP identifies quantities, timings, availabilities, procurement and production action required of materials and components to meet delivery deadlines. By coordinating inventories, procurement and production decisions MRP helps in avoiding delays in production. It helps in arranging production activities in priorities by putting due dates on consumer job orders.
- **Realistic commitments :** Realistic delivery promises can enhance customer satisfaction and make him delighted. By using MRP, production system can give information in time and likely delivery time to prospective customers. The potential customer orders can be added to the system to show the manager how the revised total loading can be handled with the existing capacity. This will result in more realistic delivery dates.
- **Increase in efficiency :** MRP provides close coordination amongst various work centres as production progresses through them. Hence production can be processed with fewer indirect personnel and fewer material interruptions. The information provided encourages production efficiencies.
- It reduces inventory cost by reducing inventory levels.

- It improves plant operating efficiency by making better use of productivity resources
- Thus, the MRP technique is used as:
  - ➢ Requirement calculator.
  - ➢ Manufacturing and planning control system.
  - ➢ Manufacturing resource planning system.

17.2.3. ADVANTAGES OF MRP

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

- **Reduced levels of inventory:** Helps in achieving better coordination among various orders for components and production plans for parent items. As a result average inventory level tends to get reduced for dependent demand items like raw materials and work in progress.
- **Better utilisation of human and non-human resources** : Provides accurate prior information; it helps in improving delivery systems, flow of work, avoiding intermittent delays and reducing manufacturing cycle times in jobs. All these result in optimum utilisation of all available resources.
- **Improved consumer service** : Enables managers to fix delivery dates that are definitely achievable. It helps in improving the company's ability to react to changes in customer orders, improve service by providing quality products at fair prices, meet assembly dates and reduce delivery time significantly.
- **Efficient financial planning** : Enables to plan effective cash flow requirements. It enables to identify bottleneck work centres or capacity constraints thus helping the operations manager to take better investment decisions
- **Better scheduling** : provides better knowledge about priorities hence better scheduling can be undertaken easily.
- **Improved vendor relations** : Enables the purchase department to know the priorities and changes in due dates for orders so that purchaser places the orders on vendors accordingly. This helps in improving vendor relations.
- **Efficient planning** : May suggest necessary changes in the Master Product Schedule (MPS) for evaluating an alternative to it. It helps

in projecting facility and equipment requirement, manpower planning etc. so that the organisation can survive and grow under competitive conditions.

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

- **Dynamic nature** : MRP is a dynamic system which is an important advantage. It reacts effectively with changing conditions. In fact it thrives on change. Changing conditions from the master schedule for several periods in future can affect not only the end item but also thousands of components. As the product system is computerised the management can make a new MRP computer run to revise production and procurement plans that react quickly to changes in customer demands as reflected in the master schedule.

- **Rational material decisions** : In order to maintain planned production schedules, planned order releases for necessary items have to be acted upon immediately. Thus, it enables the manager to take rational decisions.

17.2.4. LIMITATIONS OF MRP

MRP has certain limitations. They are as follows :

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

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

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

17.3. MANUFACTURING RESOURCE PLANNING (MRP II)

It includes all the activities required for the manufacturing purpose. It is the method for effective planning of all the resources of the manufacturing company. Ideally, it represents operational planning in units, financial planning, and simulation capability. It is also extension of closed loop MRP. MRP-II system is implemented in order to regulate and carry out the effective functioning of the plants and organizations as a whole. It is concerned with the integration of the aspects of manufacturing processes, including materials, finance and human relations. It gives centralized information of all the databases and activities carried out in the organization. The MRP-II system begins with MRP-I i.e. MRP-I is concerned primarily with the manufacturing materials while MRP-II is concerned with the coordination of the entire manufacturing, production, including the materials, finance and human relations. The goal of MRP-II is to provide consistent data to all members related to the manufacturing process as the product moves forward in the production line. It facilitates the development of a detailed production schedule known as master production schedule (MPS) that forms a backbone of the manufacturing system. It gives the specific and accurate requirements of facilities on the shop floor, the type of materials required, quantity required on the production line, the number of labour involved for that particular product, the sequence with which it will move on the line and time required for manufacturing.

17.3.1. FEATURES OF MRP-II

(1) ***Master Production Schedule (MPS) :*** It provides the detailed information about the manufacturing steps to be followed for the product planned. It specifies the stages in which the parts will move on the production line.

(2) ***Item Master Data (Technical Data) :*** It represents the specifications required for making the products, flow of materials on the shop floor, the plan made for its marketing at the dispatch. It also gives technical knowledge on the product mix for effective plant functioning.

(3) ***Bill of Materials (BOM) :*** It provides information like the final assembly of the product, material used for making the various parts, the quantity of each part to be manufactured. It also mentions the number of parts in the final product showing specifications and quality control aspects for the various parts during assembly.

(4) ***Production Resources Data :*** It gives the procedures to be followed like type of tooling, type of tooling materials required and also machine specifications for production.

(5) ***Inventories and orders :*** It provides the statistics for inventory control management and ordering steps (duration) followed for production.

(6) ***Purchasing Management :*** It represents the planning section to plan for the purchases to be made for a particular product and quantity within which it would be profitable for the organization.

(7) ***Shop Floor Control*** : It is mainly concerned with the flow line or production line that straight away shows the status of the company at the planning stage. It is mainly required to control the quantity and quality of products during production.

(8) ***Capacity Requirement Planning :*** It specifies the planning made, for the entire plant to decide the capacity that will give process specifications and also the rate of production that will make the plant capable for making profits.

(9) ***Cost Management :*** It is mainly concerned with the financial costing of the materials, man hours, and machines, purchasing, marketing and sales. It's the main foundation upon which the manufacturing of the plant stands.

17.3.2. ADVANTAGES OF MRP-II

(1) It provides centralized information for the activities carried out in the plant.

(2) The entire product planning can be made with respect to the data given at the customer level.

(3) It receives the customer requirements right from the input data and processes the same for designing stages.

(4) It exactly plans the quantity and type of materials required during production by coordinating with purchase department.

(5) It decides the number of man-hour rates for manufacturing the product.

(6) It gives the exact period of production for complex parts, so that the maximum estimation for a particular process can be decided.

17.3.3. DISADVANTAGES OF MRP-II

(1) Initial investment for the setup of the operational activities is costly.

(2) It is a very lengthy and time consuming process.

(3) There must be a fully dedicated staff for planning the activities and timely execution of the same.

(4) The initial processes of MRP-I must be full proof for timely execution of data.

17.4. ENTERPRISE RESOURCE PLANNING (ERP)

Enterprise resource planning (ERP) is business management software—usually a suite of integrated applications—that a company can use to collect, store, manage and interpret data from many business activities, including: Product planning, cost Manufacturing or service delivery Marketing and sales Inventory management Shipping and payment.

ERP provides an integrated view of core business processes, often in real-time, using common databases maintained by a database management system. ERP systems track business resources— cash, raw materials, production capacity—and the status of business commitments: orders, purchase orders, and payroll. The applications that make up the system share data across the various departments that provide the data. ERP facilitates information flow between all business functions, and manages connections to outside stakeholders.

Enterprise system software is a multi-billion dollar industry that produces components that support a variety of business functions. IT investments have become the largest category of capital expenditure in United States-based businesses over the past decade. Though early ERP systems focused on large enterprises, smaller enterprises increasingly use ERP systems.

The ERP system is considered a vital organizational tool because it integrates varied organizational systems and facilitates error-free transactions and production. However, ERP system development is different from traditional systems development.

ERP systems run on a variety of computer hardware and network configurations, typically using a database as an information repository.

17.4.1. FUNCTIONAL AREAS OF ERP

An ERP system covers the following common functional areas. In many ERP systems these are called and grouped together as ERP modules:

a) ***Financial accounting:*** General ledger, fixed asset, payables including vouchering, matching and payment, receivables cash application and collections, cash management, financial consolidation.

b) ***Management accounting:*** Budgeting, costing, cost management, activity based costing

c) ***Human resources:*** Recruiting, training, rostering, payroll, benefits, 401K, diversity management, retirement, separation.

d) ***Manufacturing:*** Engineering, bill of materials, work orders, scheduling, capacity, workflow management, quality control, manufacturing process, manufacturing projects, manufacturing flow, product life cycle management.

e) ***Order Processing:*** Order to cash, order entry, credit checking, pricing, available to promise, inventory, shipping, sales analysis and reporting, sales commissioning.

f) ***Supply chain management:*** Supply chain planning, supplier scheduling, product configuration, order to cash, purchasing, inventory, claim processing, and warehousing (receiving, put away, picking and packing).

g) ***Project management:*** Project planning, resource planning, project costing, work breakdown structure, billing, time and expense, performance units, activity management.

h) ***Customer relationship management:*** Sales and marketing, commissions, service, customer contact, call center support - CRM systems are not always considered part of ERP systems but rather Business Support systems (BSS).

i) ***Data services:*** Various "self–service" interfaces for customers, suppliers and/or employees.

17.4.2. BENEFITS OF ERP

- ERP can improve quality and efficiency of the business. By keeping a company's internal business processes running smoothly, ERP can lead to better outputs that may benefit the company, such as in customer service and manufacturing.
- ERP supports upper level management by providing information for decision making.
- ERP creates a more agile company that adapts better to change. ERP makes a company more flexible and less rigidly structured so organization components operate more cohesively, enhancing the business— internally and externally.
- ERP can improve data security. A common control system, such as the kind offered by ERP systems, allows organizations the ability to more easily ensure key company data is not compromised.
- ERP provides increased opportunities for collaboration. Data takes many forms in the modern enterprise i.e. documents, files, forms,

audio, video and emails. Often, each data medium has its own mechanism for allowing collaboration.

- ERP provides a collaborative platform that lets employees spend more time collaborating on content rather than mastering the learning curve of communicating in various formats across distributed systems.

17.4.3. DISADVANTAGES OF ERP

Customization can be problematic. Compared to the best-of-breed approach, ERP can be seen as meeting an organization's lowest common denominator needs, forcing the organization to find workarounds to meet unique demands. Re-engineering business processes to fit the ERP system may damage competitiveness or divert focus from other critical activities.

- ERP can cost more than less integrated or less comprehensive solutions.
- High ERP switching costs can increase the ERP vendor's negotiating power, which can increase support, maintenance, and upgrade expenses.
- Overcoming resistance to sharing sensitive information between departments can divert management attention.
- Integration of truly independent businesses can create unnecessary dependencies. ☞ Extensive training requirements take resources from daily operations.
- Due to ERP's architecture (OLTP, On-Line Transaction Processing) ERP systems are not well suited for production planning and supply chain management (SCM).
- Harmonization of ERP systems can be a mammoth task (especially for big companies) and requires a lot of time, planning, and money.

17.5. JUST IN TIME (JIT)

Just in Time (JIT) production is a manufacturing philosophy which eliminates waste associated with time, labour, and storage space. Basics of the concept are that the company produces only what is needed, when it is needed and in the quantity that is needed.

The company produces only what the customer requests, to actual orders, not to forecast. JIT can also be defined as producing the necessary units, with the required quality, in the necessary quantities, at the last safe moment. It means that company can manage with their own resources and allocate them very easily.

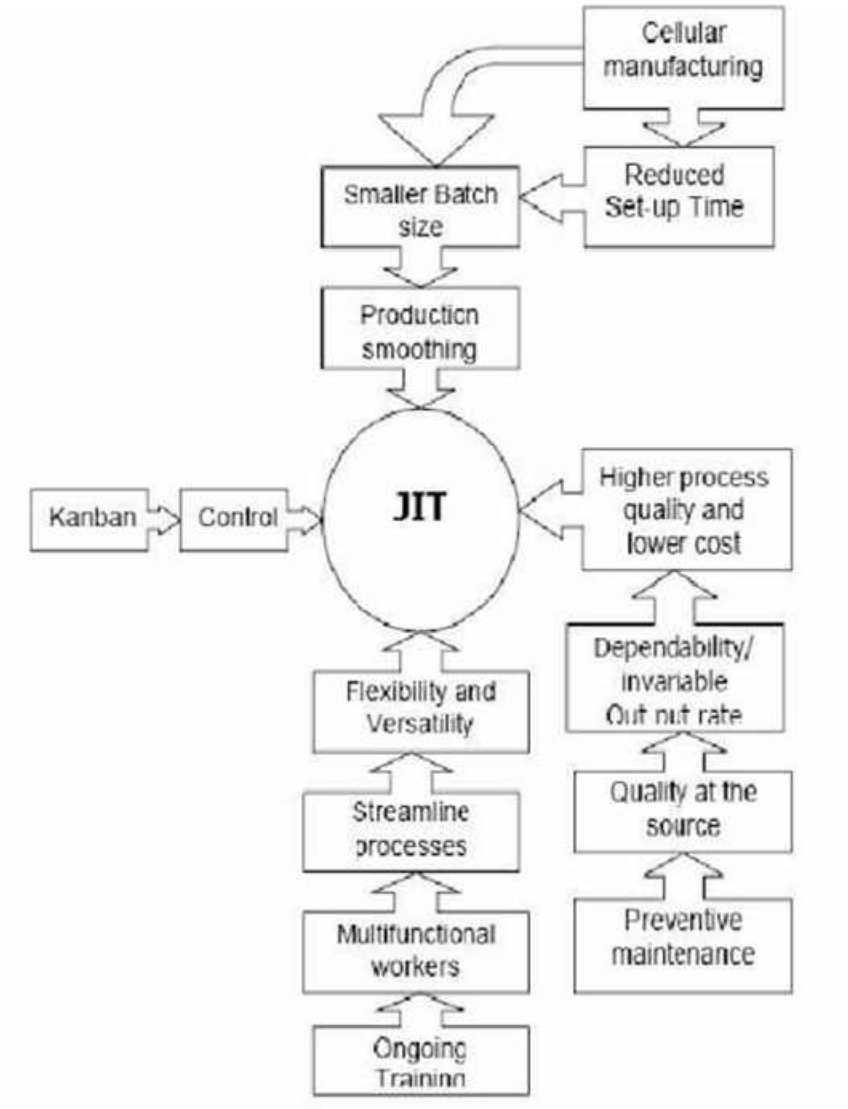


Fig : JIT System elements inter-relationship

17.5.1. BENEFITS OF JIT

Following are the benefits of JIT System:

- **Reduced set up times in store: A company, in this case, can focus on other processes that might need improvement**
- **Improved flows of goods in/through/out warehouse: Employees will be able to process goods faster.**
- **Employees who possess multi-skills are utilised more efficiently: The Company can use workers in situations when they are needed, when there is a shortage of workers and a high demand for a particular product.**

- Better consistency of scheduling and consistency of employee work hours: If there is no demand for a product at the time, workers don't have to be working. This can save the company money by not having to pay workers for a job not completed or could have them focus on other jobs around the warehouse that would not necessarily be done on a normal day.
- Supplies continue around the clock keeping workers productive and businesses focused on turnover. Employees will work hard to meet the company goals.

17.5.2. ELEMENTS OF JIT

1. ***Automation and autonomation*** : Autonomation means, "To build in a mechanism to prevent mass-production of defective work in machines or product lines. The autonomous machine is a machine to which an automatic stopping device is attached. Thus the aim is to ensure that 100% good units flow to the subsequent process, in a rhythmic, uninterrupted manner.

2. ***Buffer stock removal :*** Constant elimination of buffer stocks is emphasized to highlight production problems previously shielded by high inventory levels. These have to be resolved without delay in order to maintain production. Removal of buffers also releases space.

3. ***Cellular manufacturing :*** Many JIT factories are organized in small autonomous modules or cells, each cell being totally responsible for its own production and supply of the adjacent module. The cells are designed so that the material flow between the cells is minimized. For this purpose it is common to create 'families' of parts which are then processed by a dedicated group of machines in a cell. Within the cell, the workforce is trained to work as a group and often many functions normally considered as staff functions such as scheduling and maintenance are brought into the cell or module.

4. ***Computer integrated manufacturing :*** The use of computers to automate manufacturing operations, such as changing the type and quantity of manufactured products through minimal changes in hardware and/or software.

5. ***Continuous improvement*** : JIT is not a one-time effort. It embodies the ethics of continuous improvement, which needs to be supported by all levels of staff in the production team. JIT seeks plant wide involvement in work improvement projects. Suggestion schemes are therefore strongly encouraged and supported.

6. ***Flexible workforce*** : Flexible workforce is created through multifunctional training and job rotation. Each worker rotates

through and performs every job in the workshop to which he is assigned. In the job rotation system, all managers and supervisors are made to rotate through every job, each worker within each shop is rotated through and trained to perform each job in the shop, and scheduling of the workers through job rotation at a frequency of several times each day. Flexible workforce is necessary to match the production rate and production type as closely as possible to the market demand.

7. ***Quality :*** The achievement of high quality levels is a prerequisite of successful JIT. Commonly used quality programmes in support of JIT include:

   - Zero defects
   - Statistical process control
   - Statistical quality control
   - Process data collection,
   - Worker centered quality control,
   - Use of Poka-yoke stops devices,
   - Autonomous inspection and counting.
   - Quality circles

8. ***JIT purchasing***: Materials and components are purchased in compliance with well- defined requirements in terms of quantity, quality and delivery. JIT emphasizes small lot purchasing, vendor development, long term buyer-seller relationships; vendor involvement in product design, high quality of purchased material, frequent part delivery, cooperative transport system etc. A full-fledged JIT is virtually impossible without JIT supply.

9. ***Kanban***: It is a pull system of managing material movement comprising a 'Kanban Card' based information system. It helps trigger the movement of material from one operation to the next. Merely by altering the frequency of the circulating Kanban, the production system can be made to adjust to demand fluctuations within limits. The number of cards in the system determines the total inventory. Hence, the objective is to minimize the total number of Kanbans.

10. ***Layout changes***: The physical layout of production facilities is arranged so that the process flow is as streamlined as possible, i.e. for each component, the proportion of value added time is maximized. The flow is analysed in these terms and the layout

configured accordingly resulting in the reduction and/or elimination of stores and conveyors. Use of dedicated lines, U-shaped or parallel lines, use of small machines with multiple copies, small plants with multiple copies may be possible. Flexibility of equipment is essential to adjust quickly to changes in market demand, product type etc.

11. ***Poka yoke***: Autonomous defect control is a pillar of JIT. In this system, almost all machines are autonomous, so that mass production of defects is prevented and machine break downs are autonomously checked. Poka-yoke is one such mechanism to prevent defective work by putting various checking devices on the implements and instruments. This idea is extended to the production lines of manual work through the Andon light board system. If something abnormal happens in a product line, the worker pushes his stop button, thereby stopping the whole line.

12. ***Preventive maintenance:*** Effective JIT requires removal of causes of uncertainty and waste. A major cause of uncertainty is breakdown. Rigorous preventive maintenance attempts to remove this uncertainty.

13. ***Product and Process simplification:*** This can be achieved by two measures: the rationalization of the product range and the simplification of the methods of manufacture. Simplification is also brought about through component item standardization and component routing standardization.

14. ***Small-lots and Set up time reduction:*** JIT advocates small lot production on the basis that it allows production of daily mix of products that more closely matches demand. The object of minimizing setup times is to reduce the batch sizes to the minimum possible thus reducing manufacturing cycle time and the manufacturing inventory. This also results in release of floor space and minimizes material handling. Until the introduction of flexible manufacturing systems, however, small batch production generally not justified because it was too expensive to set up conventional, non-automated equipment for a short production run. Today, however, the driving force behind flexible manufacturing is to make it economically justifiable and technically possible to produce even a single unit. Flexible automation is a prime tool for companies that implement JIT. Setups that take hours in a traditional approach take minutes in JIT operations. Use of 'SMED'- Single Minute Exchange of Dies System-is common to set up reduction projects.

15. ***Smoothing of production***: Smoothing of production is the most important condition to achieve JIT. Production smoothing enables the system to adapt smoothly to the variations in customer demand by gradually changing the frequency of lots without altering the lot

size in each process. To achieve this, JIT systems often resort to under capacity scheduling. Flexibility of production lines can be increased to allow concurrent assembly of different models on the same line.

16. ***Standard containers:*** JIT emphasizes use of small-standardized containers. This way it is possible to greatly simplify the material movement and the use of material handling equipment.

17. ***Standardization***: The emphasis on the standardization of activities arises from balancing between processes, which is expected to improve operational effectiveness and efficiency. By standardizing job activities, resources can be focussed on only a few areas. The resulting impact on productivity can be significantly higher if one standardizes activities and concentrates organizational efforts and resources on those limited activities. Standardization of activities also reduces the time and cost of cross training employees, but the flexibility has to be maintained in order to serve the different needs.

17.6 SUMMARY

- In the recent times MRP systems have replaced conventional planning systems which were reactive inventory systems in several organisations offering several advantages over the conventional planning systems.

- Material Requirement Planning (MRP) is a material planning methodology which makes use of computer technology.

- Under the MRP system there are three major sources of information that are necessary, a Master Production Schedule (MPS) , an inventory status file and a bill of materials file.

- The key features of MRP are the creation of material requirements via exploding the bills of material and time phasing of requirements using posted average lead times.

- The main objectives of MRP are inventory reduction, realistic commitments and increase in efficiency and reduction in production and delivery lead time.

- The main advantages of MRP system over conventional inventory planning approach and fixed order system are improved customer services, reduced inventory levels and improved operating efficiency of the production departments.

- MRP cannot be applied to service systems like petroleum refineries or refilling systems, transportation companies and other non-manufacturing systems.

- MRP II is concerned with the coordination of the entire manufacturing, production including the materials, finance and human relations. It's goal is to provide consistent data to all members related to the manufacturing process as the product moves forward in the production line.

- It provides the detailed information about the manufacturing steps to be followed for the product plan. It represents the specifications required for making the products, flow of materials on the shop floor, the plan made for it's marketing at the dispatch. It all gives technical knowledge on the product mix for effective plant functioning.

- Enterprise Resource Planning (ERP) is a business management software usually a suite of integrated applications that a company can use to collect, store, manage and interpret data from many business activities including product planning, cost manufacturing, service delivery marketing and makes inventory management.

- Just In Time (JIT) is producing the necessary units with the required quality in the necessary quantities at the last safe moment. It means that company can manage with their own resources and allocate them very easily.

17.7. SELF-ASSESSMENT QUESTIONS

1. What is MRP? Discuss its advantages and disadvantages.

2. How does MRP system help the management to monitor the performance of the inventory system?

3. What are the objectives of MRP. Discuss the Components of MRP in detail.

4. Throw light on the difference between MRP and MRP II.

5. Discuss the key features of MRP II. Explain it's advantages and disadvantages.

6. Give an overview of ERP. Explain in detail the ERP modules.

7. List out the advantages and disadvantages of ERP.

8. Give an overview of JIT with suitable example.

9. Compare and contrast the philosophy of traditional and JIT purchasing.

10. What are the various benefits that company can have by practicing JIT approach. Also discuss the elements of JIT.

17.8. SUGGESTED BOOKS/ REFERENCES

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ROUGH WORK

ROUGH WORK