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PRODUCTION & MATERIALS MANAGEMENT
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BBA - III Year

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DIRECTORATE OF DISTANCE EDUCATION
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Paper - XIV
PRODUCTION AND MATERIALS MANAGEMENT
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Paper – XIV – Production and Materials Management

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TEXT BOOK:
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UNIT - I

Lesson 1.1

PRODUCTION MANAGEMENT

OBJECTIVES:

This introductory lesson on production management will help you to define production management and also understand its various functions and widening scope. You will also be presented with the contemporary issues and developments in the area of Production Management.

1.1.1. INTRODUCTION

The definition of Production management is the planning, organizing, staffing, directing and controlling all the activities of productive systems - those portions of organizations that convert inputs into products and services. These systems take raw materials, personnel, machines, buildings and other resources and produce products and services for consumers. The core of a productive system is its conversion process wherein workers, materials and machines are used to convert inputs into products and services.

In reality, there are two types of production processes, one making products using machines and other making the machine or production system itself. In the case of manufacturing industry, the former process may be called "production" and the latter, "preparation for production". In the face of rapid economic change, technological advancement and use of computers in production plants and factories, production is no longer limited to "making of goods" but it also includes "preparation for production".

1.1.2. SCOPE OF PRODUCTION MANAGEMENT

Production management is not confined to the management of plant level manufacturing practice but it calls for inter-related action covering the whole spectrum of production and pre-production activities which are responsive to changing circumstances and capable of increasing overall efficiency. It is similar to a manufacturing system which quickly responds to market needs, reduces lead-time between product development and manufacturing, or the
start-up period from product design to actual production. To get this linkage, the scope of production management has become wide enough and multitude in nature. Some of the components among the ever-widening scope of production and operations management are listed below:

1. Technological forecasting - It constitutes a market survey to identify the customer needs and a technology assessment to check for technical feasibility for, say, a new product to meet the customer needs.

2. Research and development - This activity focuses on improving the quality and efficiency of existing products, as well as the development of new products as per the customer needs and desires, thereby, striving to improve the organizational productivity and customer satisfaction levels.

3. Product planning and design - It includes evaluating market needs, creating alternative concepts for the product, clarifying operational requirements, establishing design criteria and their priorities, and estimating logistics requirements for producing, distributing and maintaining the product in the market.

4. Pre-production arrangements - Here, the production managers prepare plans for materials acquisition/procurement, warehousing and transportation. Activities go beyond just hardware considerations: This stage involves planning for production control systems, management information systems and human resource systems. Thus, the scope of production and operations management is vast and expanding.

1.1.3. FUNCTIONS OF PRODUCTION MANAGEMENT

As discussed earlier, the core of a productive system is its conversion subsystem, wherein men, materials and machines are used to convert inputs into products and services. This process of conversion is at the heart of production and operations management and therefore, this is the important function of production management. In carrying out this function, priorities are established among the following characteristics:

a) Quality (product performance)

b) Cost efficiency (low product price)

c) Dependability (reliable, timely delivery of orders to customers)

d) Flexibility (responding rapidly with new products or changes in output volume).
In carrying out his duties, a production manager, guides the entire system through decision-making. In doing so, there is a major emphasis on productivity, along with the priority areas mentioned earlier. There are various ways of classifying the decisions that a production manager must take, such as qualitative and quantitative, according to the management process (planning, staffing, etc.) and according to whether the decisions relate to system design or system operation. System design involves decisions that relate to system capacity, the geographic location of facilities, arrangement of departments and placement of equipment within physical structures, product and service planning and acquisition of equipment. These decisions usually require long-term commitments. System operation decisions include management of personnel, inventory planning and control, scheduling, project management and quality assurance. In many instances, the manager is more involved in day-to-day operating decisions than with decisions relating to system design. In fact, much of systems design lies in the province of top management. However, the production manager has a vital stake in system design because system design essentially determines many of the parameters of systems operations.

1.1.4. PROBLEMS OF PRODUCTION MANAGEMENT

A number of important issues and recent developments in the practice of production and operations management are currently influencing managerial decisions. An overview of the major ones is presented below:

1. Productivity - It has become a key measure of the effectiveness of management. Factors such as inflation and the scarcity of certain resources have generated an increased emphasis of achieving productivity gains.

2. Inflation - Uncertainty in financial markets has created problems. Inflation, high interest rates, fears of recession and speculative buying have had an effect on the vast majority of business firms and will continue to do so. Also, inflation increases the costs of inputs as well as the costs of transformation. Such conditions have made industrial expansion difficult because new debt and stock issues have been prohibitively expensive and the availability of funds has been uncertain.
3. Increasing scarcity of certain resources - Particularly energy scarcity, can have a profound effect on operations. This is often reflected by efforts to upgrade existing facilities to make them more energy-efficient and to incorporate energy-efficiency in the design of new facilities. Similarly, emphasis in product design is on energy-efficient products.

4. International scope of productive systems - It has resulted in increased opportunities to develop foreign markets, created additional sources for raw material and labour inputs, and forced numerous organizations to re-assess their strategies. It has also brought increased competition from foreign companies.

5. Dominance of service systems - The emergence of a variety of organizations to supply services to the growing population is perhaps the most dramatic fact of today's organizations. Managers are adapting many of the planning, analyzing and controlling techniques traditionally used in goods-producing systems to these new systems that produce intangible outputs. But many traditional techniques do not apply, and new ones must be developed and tested.

6. Customers' demands upon production and operations management - Increasingly, customers demand more from production and operations. Special product or service designs, accelerated delivery dates, custom packaging, specific shipping requirements and last-minute order changes are examples of these demands. Today, managers are judged as good, if their production and operation systems are highly efficient (low cost) and responsive to customers' demands.

7. Government regulations - Pollution control has had a tremendous impact on some industries in terms of design and operation, and the government continues to strengthen standards on waste disposal and emission controls. As a result, the firms are forced to create special designs and pricing policies to compensate for them.

8. Increased use of computers - It has enlarged the decision-making capabilities of managers, enabling them to use more quantitative techniques in analyzing decisions and has greatly enlarged information storage and handling capabilities. This has also generated a training need for the personnel and additional investment.

1.1.5: SUMMARY

A production manager's job is different from the jobs of general managers because of his close ties to the productive systems. These systems convert
inputs such as materials, labour, capital and utilities into outputs that are their products and services. Production management is not confined to the management of plant level manufacturing practice alone but it calls for inter-related action covering the whole spectrum of production and pre-production activities. Current issues in this area include an increased emphasis on service systems, dealing with the scarcity of resources, contending with high costs of funds and energy and operating under increasing competition and changing governmental regulations.

1.1.6. SUGGESTED READINGS


QUESTIONS

1. Define production and operations management.

2. What are the contemporary issues and developments that influence the managerial decisions concerning production and operation?

3. Discuss the scope of production and operations management.

4. What are the key decisions taken by a production manager relating to:
   a) Production system design
   b) Production system operation

5. Describe the primary inputs, outputs and conversion subsystems of the following organizations:
6. Name two organizations that have no production functions. Defend your answer.

7. What is the overall objective of the operations subsystem? What are its sub-goals? How do they relate to each other?
Lesson 1.2.

PRODUCTION SYSTEMS

OBJECTIVES:

This lesson attempts to present to you the Production function as a system. You will also learn the features of the systems concept and the types of Production systems along with different methods of categorizing them.

1.2.1. INTRODUCTION

An important basis for unifying and relating the complexities of managerial problems is the system concept and methodology. This has been applied more to the analysis of production systems than to other fields. This is because a production system involves a complex of interacting components, and we gain insight into what really makes the overall firm run by focussing on the system rather than simply studying the components. The word "system" is descriptive of the general interacting nature of the number of elements that enter managerial problems.

1.2.2. PRODUCTION AS A SYSTEM

Production is an organizational function which is usually responsible for the management of a process or procedure intended to convert a set of inputs into a predetermined set of outputs in the form of goods and services in accordance with the objectives assigned to the management. Figure 1.1. shows a model illustrating the production systems concept. This function starting from resource inputs to end outputs is a highly complex activity divided into various segments which are inter-related to each other. It is, due to this complexity of large-scale activities/operations, almost impossible to view the many segments of the production function solely as a group of separate entities within the total organization, and ignore the inter-relationships that exist among the functional components of the organization.

The definition of Production system is therefore modified to include the system concept by stating that Production system is a design and control
process by which resource inputs are transformed to create useful goods and services. In fact, the Production system is one of transformation or conversion process. It contains two subsystems, i.e. sets of components and inter-relationships viewed as components of an aggregated large system. The conversion process is one subsystem while the second is control subsystem which is a component of any managed system. It involves the feedback of information from the output of the converter to an information processor.

1.2.3. TYPES OF PRODUCTION SYSTEMS

There are different types of production system since the choice of production type dictates the organizational system and to a large extent, its layout, planning and inventory, and sub-systems. There are traditionally three main types of production systems, namely Job, Batch and Flow or process production systems. There are five typical methods of categorizing the Production systems. The simplest way to classify the production processes is by lot size, namely single-unit production, small lot production, medium lot production, large lot production and continuous production. The second method of classification is to determine whether the production process is continuous or intermittent. The third classification comprises three categories, namely small-scale production of a large variety of products, medium-scale production of a limited range of products and a large scale production of a small variety of products. The fourth classification is related to order booking. This method comprises job order production and production to stock. The fifth classification is related to the size of the production system expressed through the number of employees or the amount of fixed assets involved. However, if traditional and non-traditional types as classified, are considered in revision, then Job and Batch production systems come under the intermittent type, while Flow production system falls under the category of continuous type. They are briefly described below to indicate the main features of the different production systems.

1. **Job Production System**: Job, “one-off”, project or “make complete” production is the manufacture of a single complete unit by an operator or group of operators. Bridge building, ship building and installing capital plant in factories are common examples of this type of production, even though in these examples, Batch production techniques are being used. It has the following special characteristics:
Fig. 1.1 - A Productive Systems Model

The resources in a job shop are general rather than specialized. Basic materials with different specifications can be used in many different jobs.

Equipment should be adaptable to different uses.

The skills of the employees would be wide enough to enable them to work on any job within their area.

2. Batch Production system: Here, the work on any product is divided into operations. It means, the work content of each unit is broken into a number of operations, not necessarily of equal work content, and the operators are again divided into groups. The Batch production technique is the most common type of production, typical examples being the production of electronic instruments. The salient features of Batch production are summarized below:
Some degree of specialization of labour is possible.

Capital investment is low and flexibility is high.

The planning required to ensure freedom from idle and waste time is considerable.

The production control department can derive greatest benefits.

The work-content of the material increases irregularly and results in a substantial work-in-progress.

There is always a rest period for each unit in the batch, while work is proceeding on other members of the batch, and another rest period while the whole batch is in buffer store.

3. **Flow or Process Production System**: It is characterized by the continuous flow required by the production technology. In other words, Flow production can be defined as production during which the work content of the product continually increases. As the work on each operation is complete, the unit is passed to the next work stage without waiting for the work to be complete on the entire batch. The automobile and petroleum industries are good examples of Flow Production. It is viable only when the following requirements are met:

- There is substantially constant demand.
- The production process is standardized.
- The material is made to specification and delivered in time.
- All operational stages are defined and balanced.
- Work conforms to quality standard.
- The correct plant and equipment are provided at each stage.
- Maintenance is undertaken by anticipation and not by default.
- Inspection is “in line” with production.

4. **Mass Production System**: This term is often loosely used to imply a particular type of production on a large scale. As such, it may come under either Job, Batch or Flow production methods. The advantage in favour of this type of production is that if a small number of small factories, all producing identical articles join into one large unit producing the same total quality of the same article, it is possible to increase considerably, the effort of work study, tooling, plant, inspection and production control resulting in considerable decrease in cost of all factors of production.
1.2.4. SUMMARY

The function of Production Management is that of putting together inputs of men, capital, materials, information and energy; and transforming them into products and services in the quantity, quality, time and location that will best meet organization's objectives. Its complexity is best studied by developing a conceptual framework which more precisely and effectively ties together all functional efforts, contributions and knowledge with a common goal. This is what is called a Systems concept. Traditionally, there are three main types of Productions systems, namely Job, Batch and Flow or Process Production systems. They could further be classified by different methods of categorization based on, say, lot size, nature of work flow, scale of production, order booking and size of the production system.

1.2.5. SUGGESTED READINGS


QUESTIONS

1. State clearly "System concept" indicating its advantage.

2. What are the different types of Production systems? Discuss each of them stating their special features and suitability.

3. Illustrate with examples, the various methods of categorizing the production systems.

4. "Students are processed (educated) in batches (classes). In that respect, a University is a giant job shop production system". Do you agree or disagree with this statement? In what respect is a University similar or dis-similar to a printing shop?
2.1 INTRODUCTION

Production Planning and Control is the organization and planning of the manufacturing process. It co-ordinates supply and movement of materials and labour, ensures economic and balanced utilization of machines and equipment as well as other activities related with production to achieve the desired manufacturing results in terms of quantity, quality, time and place.

Production planning implies formulation, co-ordination and determination of activities in a manufacturing system necessary for the accomplishment of desired objectives whereas production control is the process of maintaining a balance between various activities evolved during production planning providing most effective and efficient utilization of resources.

2.2 PRODUCTION PLANNING

Production Planning is composed of two words ‘Production’ and ‘Planning’. Production is concerned with the activities of any manufacturing system and planning implies co-ordination, formulation and determination of these activities for the accomplishment of the desired objective. Production planning is that function of management which decides about the resources the firm will require for its future manufacturing operations and of allocating these resources to produce the desired output in required amount at least cost. Production planning sets the frame work within which detailed schedules and inventory control schemes must operate.

The necessity of production planning arises for strictly managing internal operations to manufacture goods/services in the face of outside demand and constraints. In multi-plant operations production planning includes decisions with reference to the amount of each item to be made in each of the plants.

Pre-requisite for production planning is decision regarding the method of production i.e. pre-planning about the type of product and its design and the amount of output.
Alternately, production planning is necessary for directing and controlling the methods used for production and deals with the setting-up of production facilities viz. building, machine, equipment etc. in available space. It involves pre-determination of manufacturing requirements such as material, money, order priority, production process etc. for efficient production of desired goods/services. Planning is projecting appropriate action well in time about some predetermined objective together with means necessary to achieve the objective. It involves study of various alternatives and to select the best alternative under a set of conditions using logistics.

**LEVELS OF PRODUCTION PLANNING:**

Production planning can be done at three levels namely Factory Planning, Process Planning and Operation Planning.

(i) **Factory Planning:**

At this level of planning, the sequence of work tasks is planned in terms of building, machines and equipment required for manufacturing the desired goods and services. The relationship of workplaces in terms of departments is also planned at this stage taking into consideration the space available for the purpose. The stage deals with Plant location and layout.

(ii) **Process Planning:**

There are many operations involved in factory planning for transforming the inputs into some desired end product. In process planning these operations are located and the sequence of these operations in the production process is determined. Plans are also made for the layout of work centres in each process.

(iii) **Operation Planning:**

It is concerned with planning the details of the methods required to perform each operation viz. selection of work centres, designing of tools required for various operations. Then the sequences of work elements involved in each operation are planned. Specifications about each transfer, work centres, nature of tools required and the time necessary for the completion of each operation are prescribed.
PLANNING AND MANUFACTURING SYSTEMS:

The method of production planning basically depends on the nature of manufacturing systems. The manufacturing systems can be classified into three main categories, namely

(i) Continuous type like rayon, cement paper plants.
(ii) Intermittent type like automobiles, typewriters, locomotives plants.
(iii) Non-standardised job-shop types of plants producing parts for various industries.

In continuous types of manufacturing systems planning is rather easy. Here one has to decide only about what to produce and when to produce. How and where aspects are inherent in the system itself. More emphasis is laid on mechanisation.

Planning is more complicated in intermittent type of plants. The same machine can be used to manufacture different types of components and one is faced with the problem to plan the operations in such a way that all the machines can be used in the most efficient manner. Again, the various components of the system work independently and there is necessity of proper co-ordination between them e.g. a sub-assembly process is not complete unless various parts produced by other sections of the plant are completed.

The nature of equipment and machines required for manufacturing items in the non-standardised type of plants determines the process of planning.

The fundamental objective of planning in all the three systems is “maximum utilization of plant capacity to produce maximum output”.

OBJECTIVES OF PRODUCTION PLANNING

The fundamental object of production planning is to produce right types of material both in quantity and quality at the right time, using the most appropriate method of production in the most effective manner. The various objectives or goals of production planning can be listed as:

(a) systematic co-ordination and regulation of various activities keeping in view the capacity of the resources and the objective of the organisation.
(b) to maintain proper balance of the activities for efficient production.
(c) determination of raw material, machines, equipment etc. and other input requirements for desired output.
(d) anticipation of business changes and reacting to them in proper manner.
(e) to have optimum use of the resources with optimum cost and time by having most economical combination.
(f) to provide alternative production strategies in the case of emergencies.

**STEPS FOR PRODUCTION PLANNING**

The fundamental objectives of production planning is the maximum utilization of plant capacity in most economical manner, can be accomplished by taking proper decisions regarding selection of right type of raw materials, equipment, machines and economic order quantity of output in one given lot. Production plans are designed to fix some or all of the characteristics of manufacturing and distribution operations by determining the general size of labour force, setting plant and equipment capacity etc. Production planning involves study of various alternatives to get the desired output and to select the best alternative under a set of conditions using logistics.

Broadly speaking, the planning procedures concern themselves with the best methods to be applied for decisions regarding right type of products and the most economic quantities to be manufactured in one given lot. Production planning prepares procurement plans for material and personnel, establishes stock room procedures and controls, prepares and issues work authorization, establishes finished goods inventory control and maintains alternative under plans of action.

**Nature of preliminary information necessary for efficient production planning:**

The information vital and valuable for planning the production strategy of an enterprise can be classified in following categories:

(1) Information regarding product design, the nature of the production process to get the desired product.

(2) Details about the quality and the quantity of raw materials required to produce the product.
(3) Specifications of various types of tools, machines and other equipment needed for production.

(4) Average and maximum plant capacity under different circumstances.

(5) Rate of obsolescence and loss in storage.

(6) Information about work analysis and performance rating of workers.

(7) Rate of interest on capital invested.

(8) Details of new development in production technology, if any.

(9) Prices of materials, wages of labour and overhead expenditure per unit of output.

(10) Hourly, daily, weekly and monthly output rate.

(11) The demand requirement of the product and due date or period of delivery.

(12) Training requirements of the product and due date or period of delivery.

(13) Training requirements to workers.

(14) The best sequence of operations so as to minimize the cost of production.

(15) Specific policies of the enterprise in relation to personnel and other production aspects.

The availability of these information will facilitate the planning department to chalk out suitable production strategy.

Planning procedures can be broadly divided in three cases:

Routing prescribes the sequences of operations required to transform inputs into desired output.
Scheduling when and where each operation of the production process is to be performed.
Loading studies relationship between load and capacity of work centres in the system.

Importance of Production Planning

The success and growth of any organisation mainly depends on planning. In present world there is touch competition, rapid development in technology and quick changes in human behaviour and daily requirements. Due to these factors there is lot of uncertainty associated with every system and to counter balance it, production planning becomes a valuable phenomenon.
Koontz and O Donnel have emphasized that “Planning may be likened to navigation. The navigator lays out a plan and sets a course towards an objective. But his job is not completed by doing so. Instead, he constantly reaches his position as he proceeds towards his goal, modifying his plan as errors or unforeseen circumstances prove that his course is leading to some point other than the goal sought”.

There can be a number of alternative choices for the enterprise and production planning measures can be applied to select the most appropriate set of alternatives taking into consideration the resources of the enterprise. Mathematical techniques can be used to determine the optimum choice when the situation is normal and certain, but in the case of uncertainties associated with the phenomenon planning should be done with provision of modification to meet out the risks.

Planning ensures most efficient resources viz. material, capital, and labour. It tries to distribute the work load in such a manner that there is uniform use of resources during peak as well as dull periods of demand for goods and services. Planning provides basis for effective production control. Planning formulates the production schedule and fixes the targets in terms of time and effort for each operation i.e. the work standards are formulated. The control operations can be applied to measure the planned performance of the operations.

There is evident that planning occupies an important place in management of production process. The level of performance as well as the success of an enterprise depends on effective planning.

Following are the main characteristics of a good planning procedure:

(i) It should have a well-defined objective.
(ii) It should be simple and easy to apply in practice with flexibility to adjust in changing situations.
(iii) Reliable and up to date information should be available for planning the process.
(iv) It should be capable of laying down appropriate standards and targets for effective control of the operations.
(v) It should be based on sound decision making principles.
2.3 PRODUCTION CONTROL

Definition of Production Control

There is lot of disagreement between different experts of management regarding the meaning of production control. In literary sense control means action to check/regulate. In the opinion of Mary Cushing Niles, “Control is maintaining a balance in activities towards a goal or set of goals evolved during production planning”. Planning only outlines some course of action whereas control is an execution process involving standardization, evaluation and corrective functions.

According to Fayol: “Control consists in verifying whether everything occurs in conformity with the adopted plan and established principles”. The objectives of control is to point out weaknesses and shortcomings, if any, in order to rectify them and prevent recurrence. It operates on everything viz. material, equipment, men, operations etc.

The production control is some scientific procedure to regulate an orderly flow of material and co-ordinate various production operations to accomplish the objective of producing desired item in right quantity of desired quality at the required time by the best and the cheapest method i.e. to attain highest efficiency in production.

Alternately, production control is the function of management which directs and controls the material supply and processing activities of an enterprise; so that specified products are produced by specified methods to meet an approved sales programme. It ensures that the activities are carried in such a way that the available labour and capital are used in the best possible way.

Objectives of Production Control

The success of an enterprise greatly depends on the performance of its production control department. The production control department generally has to perform the following functions:

1. Provision of raw material, equipment, machines and labour.
2. To organise production schedule in conformity with the demand forecasts.
(3) The resources are used in the best possible manner in such a way that the cost of production is minimized and delivery date is maintained.

(4) Determination of economic production runs with a view to reduce setup costs.

(5) Proper co-ordination of the operations of various sections departments responsible for production.

(6) To ensure regular and timely supply of raw material at the desired place and of prescribed quality and quantity to avoid delays in production.

(7) To perform inspection of semi-finished and finished goods and use quality control techniques to ascertain that the produced items are of required specifications.

(8) It is also responsible for product design and development.

Thus the fundamental objective of production control is to regulate and control the various operations of production process in such a way that orderly flow of materials is ensured at different stages of the production and the items are produced of right quality in right quantity at the right time with minimum efforts and cost.

**Techniques of production Planning and Control:**

There are several techniques for production planning and control.

The technique which are used for production planning are as follows.

- Forecasting
- Aggregate planning
- Master production schedule
- Order writing
- Product design
- Masterials Requirement Planning, etc.
- Process planning and routing
- Materials control
- Tool control
- Scheduling

The techniques for production control are as follows.

- Progress reporting
- Corrective action
The tasks under progress reporting are data processing, order control and machine loading chart. The tasks under corrective action are creating schedule flexibility, schedule modifications, capacity modifications, make or buy decision, expediting the work and preplanning.

QUESTIONS

1. Explain the importance of production planning.
2. What are the objectives of production planning?
3. Discuss the steps for production planning.
4. Discuss the nature of preliminary information required for efficient production planning.
5. Define production control.
6. What are the objectives of production control?
7. List the techniques of production planning and control.
UNIT - III

PRODUCTIVITY

3.1 PRODUCTIVITY

Policy formulation in modern times has become a very complicated and time consuming phenomenon. Business enterprises now-a-days wants to plan their future strategies from its past performance. There are number of measures viz. Productivity, Profitability rate of return etc. to illustrate the past performance. All these indicators are some sort of direct or indirect relationships between input and output factors. But none of the measures is able to determine or evaluate the overall performance of an enterprise. In this section one of these measures namely Productivity is discussed in detail.

The only way of raising the living standards of the society is to increase productivity. Productivity can be increased by increasing output from each unit of input.

3.2 CONCEPT OF PRODUCTIVITY

In general sense, productivity is some relationship between inputs and output of an enterprise. It is the quantitative relationship between what we produce and the resources used. The concept of productivity measurement is many sided. It can relate to every item/activity on which money is spent to get the final product. Some of the definitions given below explain the fundamental concept of productivity.

3.2.1 Definition of Productivity

(i) Productivity is a measure of how much input is required to produce a given output i.e. it is ratio of output to input.

(ii) Productivity is the ratio between the amount produced and the amount of resources used in the course of production. The resources may be any combination of materials, machines, men and space.

(iii) European Productivity Council defines “Productivity is an attitude of mind. It is a mentality of progress, of the constant improvement of that which exists. It is the certainty of being able to do better than
yesterday and continuously. It is constant adaptation of economic and social life to changing conditions. It is the continual effort to apply new techniques and methods. It is the faith in human progress”.

(iv) According to Peter Drucker, “Productivity means a balance between all factors of production that will give the maximum output with the smallest effort”.

(v) Organisation of European Economic Community (OEEC) defines productivity as the ratio between the production of given commodity measured by volume and one or more of the corresponding input factors also measured by volume.

Thus there can be a number of measures indicating the level of performance corresponding to each input. In general sense, productivity is a measure of how much input is required to produce a given output i.e.

\[
\text{Productivity} = \frac{\text{Measure of output}}{\text{Measure of input}}
\]

Input in a business organisation can be labour, capital, etc. The measures can be expressed in terms of money value or in terms of quantity.

In most cases output will be goods and services produced, for which input will be men, money, equipment, power, plant facilities and other items used in the process of production. Total productivity of the firm can be defined as

\[
P_T = \frac{Q_T}{L + C + R + M}
\]

where \( P_T \) = Total productivity
\( L \) = Labour input
\( C \) = Capital input
\( R \) = Raw material and purchased parts input
\( M \) = Other miscellaneous goods and service input factors
\( Q_T \) = Total output

All input and output factors are measured in some common unit. Productivity is a measure of how well the resources are utilized to achieve given objectives.
3.3 IMPORTANCE OF PRODUCTIVITY

The concept of productivity is of great significance for undeveloped and developing countries. In both the cases there are limited resources which should be used to get the maximum output i.e. there should be tendency to perform a job by cheaper, safer and quicker ways. The aim should be optimum use of resources so as to provide maximum satisfaction with minimum efforts and expenditure. Productivity analysis and measures indicate the stages and situations where improvement in the working of inputs possible to increase the output.

The productivity indicators can be used for different purposes viz. comparison of performances for various organizations, contribution of different input factors, bargaining with trade unions etc.

3.4 MEASUREMENT OF PRODUCTIVITY

There are a number of ways to measure productivity. The main criterion of measuring productivity are:

(i) In terms of input performance by calculating changes in output per unit of input.
(ii) On the basis of output performance by calculating change in input per unit of output.

Following are some of the measures in common use:

a) Labour productivity = \( \frac{\text{Amount of output}}{\text{Amount of labour}} \)

where output can be measured in total quantity produced and labour can be measured in total man-hours required to produce that output. Output and labour can also be measured in terms of their value in money units

b) Capital productivity = \( \frac{\text{Turn over}}{\text{Capital Employed}} \)

c) Profit productivity = \( \frac{\text{Profit}}{\text{Investment}} \)
d) Energy productivity = \[ \frac{\text{Output}}{\text{Quantity of energy used}} \]

e) A general measure of productivity can be defined as

\[ \text{Productivity} = \frac{\text{Output}}{\text{Labour + Capital + Other inputs}} \]

3.5 TOOLS OF PRODUCTIVITY

Productivity can be increased in a number of ways. It can be increased either by reducing the input for the same level of output or by increasing the output with the same level of input or by combination of both. This can be achieved by elimination of waste, by using improved technology, better production design and management efforts. There can be increase in productivity by reducing downtime of maintenance, reduction in material input, better quality of goods, improved utilization of resources, reduction in working capital requirements, reduction in inventory size, improvement in manpower skills through training etc. Output can be increased by better leadership management. When employees are better motivated, output can be increased.

Decision making is a key factor which affects productivity. Better decisions obtained through adequate and timely information systems definitely will improve effectiveness and efficiency of the organisation.

There are many productivity improvement techniques and research methods to aid the collection information about productivity, all with the ultimate aim of improving it. This information is used as a means of changing and improving upon the current position. Some of the techniques are quantitative. i.e., they lead towards technical and numerical assessments, while others are qualitative with a bias towards the subjective.

From the many techniques available, 21 have been selected as being of practical use in productivity investigations. These techniques are briefly summarized below.
<table>
<thead>
<tr>
<th>NO TECHNIQUE</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Flow process charts</td>
<td>Study of flow and sequencing of people and materials. Reveals how unnecessary activities can be reduced.</td>
</tr>
<tr>
<td>2. Flow Diagrams</td>
<td>Routing and sequencing of people and materials.</td>
</tr>
<tr>
<td>3. String Diagrams</td>
<td>Reveals degree of complexity of movement and hence how to remove congestion.</td>
</tr>
<tr>
<td>4. Man/Machine activity charts</td>
<td>Used for finding a better balance between people and equipments.</td>
</tr>
<tr>
<td>5. Two-handed operator charts</td>
<td>Reveals how individual operations can be improved.</td>
</tr>
<tr>
<td>6. Micro-motion study</td>
<td>A technique for improving the minute aspects of individual operations.</td>
</tr>
<tr>
<td>7. Value Analysis</td>
<td>Especially useful for analyzing the functional and cost effectiveness of products and services.</td>
</tr>
<tr>
<td>8. Estimating</td>
<td>Useful for providing quick estimates of time, generally subjective and therefore inaccurate.</td>
</tr>
<tr>
<td>9. Time study</td>
<td>A method for obtaining objective time standards, most suitable for repetitive operations.</td>
</tr>
<tr>
<td>10. Synthetics</td>
<td>Cheaper than time study for providing accurate time standards. Can be developed internally.</td>
</tr>
<tr>
<td>12. Activity Sampling</td>
<td>Particularly useful in productivity studies for percentage of time spent on</td>
</tr>
</tbody>
</table>
13. Pareto Analysis

productive/ancillary work and idle time.
Useful for identifying areas which incur the greatest cost, time and scrap. Main applications are purchases, stock and scrap.

14. Work Simplification

A participative use of method study. A form of quality circles effective for releasing creative potential.

15. Critical Incident Analysis

An open-ended approach to revealing productivity problems.

16. Illuminative Incident Analysis

A team and pictorial method for understanding human problems affecting group effectiveness.

17. Questionnaire

Used for studying the attitudes affecting productivity.

18. Layout Design Technique

Used for designing the layout for new plants and for improving the layouts for existing plants.

a. Computer processed layout design technique

- CRAFT (Computerized Relative Allocation of Facilities Technique)
  Used for improving the existing layouts.

- ALDEP (Automated Layout Design Program)
  Used for designing new layouts.

- CORELAP (Computerized Relationship Layout Planning)
  Used for designing new layouts.

b. Assembly Line Balancing

Used to subdivide the whole assembly line into a reasonable number of stations in such a way that the line efficiency is maximized.
c. Cellular Layout Design

Helps to identify families of components that require similar processing on a set of machines. These machines are grouped into cells, where each cell would be capable of satisfying almost all the production requirements of the component families assigned to it.

Helps to develop a Just-In-Time (JIT) system, where all necessary information arrives on time at the place where action is to be taken. This system helps to produce goods in the required amount, at the required time, at the lowest cost and at the highest quality.

20. Flexible Manufacturing System (FMS)

Used to develop a manufacturing system which will be able to adapt quickly to the changes in the product design / product mix. FMS integrates several machine centers to achieve this objective.

21. Computer Integrated Manufacturing (CIM)

Used to control the total production system using a central computer. CMS will integrate several FMSs. Using CIM, “Unmanned factory of the future” could be achieved.

3.6 FACTORS AFFECTING PRODUCTIVITY

All the factors which are related to input and output components of a production process are likely to affect Productivity. These factors can be divided into two main categories, namely

**Category I:**

[a] Primary factors are effort and working capacity of an individual.
(b) Organisational factors are related to the design and transformation process required to produce some item, the nature of training and other skill imparted to workers to perform certain operations in a production process, control and various other incentives.

(c) Conventions and traditions of the organisation e.g. activities of labour unions, medical facilities, workers and executives understanding etc.

**Category II:**

(i) Factors related to output research and development techniques, improvement in technology and efficient sales strategy of the organisation will lead to improvement in output.

(ii) Efficient use of input resources, better stores control, production control policy, maintenance of machines etc. will minimise the cost of production.

The factors listed in categories I and II can be further divided in four major classes viz. (i) Technological, (ii) Managerial, (iii) Labour and (iv) External factors.

The technological factors can increase the output per unit of input substantially. These can be defined in terms of technology employed, tools and raw material used etc.

Managerial factors can be located in organisational structure, scheduling of work, financial management layout, innovations, personnel policies and practices, work environment, material management etc.

Labour factors are characterized by the degree of skills of the work force, health, attitude towards management, training, discipline. Greater the congruence between the skills of work force and technology employed better would be the productivity.

External factors are innumerable in the environment with which an organisation has to interact e.g. the power and transport acilities, tariffs and taxes etc. have important bearing on the levels of productivity.

Some of these factors are controllable and some are uncontrollable and a demarcation should be made between the two.
3.7 PRODUCTION AND PRODUCTIVITY

Each kind of measure needs some specific kind of information. The appropriate measure can be selected on the basis of the information available and the objective of the investigation. In fact, the measure of productivity indicates the performance of inputs namely, labour and capital in an enterprise. Increase in output is not an indication of increase in productivity. Production is an absolute measure and productivity is a relative measure.

QUESTIONS

1. Define productivity
2. Explain the importance of productivity.
3. Discuss different measurements used for productivity.
4. Briefly discuss various tools for productivity improvement.
5. Discuss the factors which are affecting productivity.
6. Distinguish between production and productivity.
UNIT - IV

MODULES OF PRODUCTION PLANNING AND CONTROL

4.1  MODULES OF PRODUCTION PLANNING AND CONTROL

4.1.1  PRODUCTION ROUTING AND SCHEDULING

4.1.1.1  ROUTING

"Routing means determination of path or route over which each piece is to travel when it is transformed from raw material into finished product".

Evidently where one single product or part is manufactured by a fixed set of machines, the job or routing becomes mechanical. In continuous manufacturing systems with fixed line layout, it needs no managerial effort for routing, though different sets of machines are used in manufacturing the product in such systems. But intermittent type of systems, routing is a complex task when different kinds of products are to be manufactured. Routing of a production order contains a complete description of the item to be manufactured, details of each operation involved in the process, the setup time and the standard time required to complete the work. It also determines the type of machines needed to perform each operation and also alternative machines in case of emergency. The precedence of various operations involved in the process is also prescribed. Here various operations involved in the process are also prescribed. Here for every item or batch of production the production process should be outlined on different route sheets.

Routing also prescribes the amount of material, types of equipment and machines and the number of skilled and unskilled workers required to perform a particular job or operation.

Actually routing is the basis for scheduling and loading. In the words of Sprigal and Lansburg, "Routing includes the planning that where and by whom the work shall be done. It determines the path that work shall follow and prescribes the sequence of operations. It forms the basis for scheduling and functions of planning".
In general routing consists of seven decisions, namely

1. Whether to make/buy.
2. The form and shape of the material.
3. The division of work to be done into operations.
4. The choice of machines/work centres on which each operation should be done.
5. The sequence in which operations are to be performed.
6. The division of operations into work elements.
7. The choice of special tooling.

Routing consists of following steps:

(a) The product is fabricated into sub-components to decide that which components can be produced inside the plant and which parts are to be purchased from outside i.e., to manufacture or to buy decision is made.

(b) The decision that which components can be manufactured by the organisation will determine the requirement of inputs i.e. material, labour etc. The production process of transforming inputs into output is then outlined in the form of drawing as a route sheet using different symbols and notions for identification. Preliminary test can be made to ascertain the amount of inputs actually required to produce the desired output.

(c) The next step is to determine various operations involved in the transformation process and then to list the sequence of these operations on the route sheet.

(d) The duration and the nature of equipment and machine required for each operation is determined.

(e) The economic lot size of production order quantity is calculated.

(f) The amount of waste which depends on the scraping factors is estimated.

(g) The various types of performs to record the details of production process at different stages of production are also designed. The format of these performs depends on the type of manufacturing system.

It can be observed from the steps outlined above that routing mainly depends on the nature of manufacturing system, availability of plant equipment and its component parts, human resources etc.
In a manufacturing plant, the routing of an order is generally spelled out on route sheets. There is great similarity between route sheets and operation process charts. A route sheet contains a complete description of the item to be manufactured, the details of each operation required in manufacturing process, the setup time and standard operation time etc. The route sheet also specifies the machines to be used and the possible alternatives wherever feasible. Route sheet also provides the sequences of various orders as well as the best/optimum sequence for the desired operations taking into consideration the resources available. This can be done by sequencing, assignment, critical paths and PERT methods.

The following points should be kept in mind for drawing route sheets:

1. the machines are to be operated at full capacity.
2. the product passes through those work centres which are manned by best possible personnel.
3. the route is shortest and most economical.
4. the person solving routing problem should be well acquainted with various operations.

A specimen of Route sheet is given below:

<table>
<thead>
<tr>
<th>Route Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing Order No.</td>
</tr>
<tr>
<td>Description of the Item</td>
</tr>
<tr>
<td>No. of pieces on order/Economic lot size</td>
</tr>
<tr>
<td>Material Description</td>
</tr>
<tr>
<td>Purchase Order No. Time/Piece</td>
</tr>
</tbody>
</table>
Advantages of Routing are:

1. efficient use of available resources.
2. reduction in manufacturing costs.
3. improvement in quantity and quality of the output.
4. provides a basis for scheduling and loading.

4.1.1.2 Scheduling

Scheduling is the process of prescribing when each operation in a production process is to be executed. In other words, it involves designing the time table of manufacturing activities indicating the time required for the production of units at each stage. According to Sprigel and Lansburg, “Scheduling involves establishing the amount of work to be done and the time when each element of the work will start”. It is nothing but, “The determination of time that is required to perform each operation and also the time required to perform the entire series as routed is scheduling”. Thus scheduling can be termed as

1. a description of when and where each operation in a production process is to be executed.
2. establishment of time-table at which to begin and/or complete each event or operation comprising any procedure.

Objectives of Scheduling:

The fundamental objectives of scheduling is to arrange the work of the production unit in such a way that (i) items are delivered on due date and (ii) the production cost is minimum. In general, scheduling may be carried out to meet the following

Objectives:

(i) to plan the sequence of work such that delivery date is met.
(ii) to have minimum throughput time for having better utilisation of resources.
(iii) to minimise idle time of machines, labour etc. for having maximum utilisation of plant and reducing the cost of wages.
(iv) to prevent unbalanced allocation of time among various departments and work centres.
Classification of Schedules:

(1) **Operation Schedule**: Operation schedule determines the total time, indicates the time required to perform as well as other details to type of materials, machines, labour etc. required for each and every operation.

(2) **Master Schedule**: Master Schedule is a list showing how many of each item to make in each period of time in future. These are usually changed as time moves along in response to change in conditions. It is the first step towards planning for Production. Here on the basis of sales forecast and levelling of production, the quantities to be produced are determined. It is initially based on the released and planned orders and is then refined by the iterative process with the use of flow charts. After finalising master schedule each customer's order can be verified for the proposed delivery date and the promises made.

The nature of master schedule depends on whether the manufacture is to order or to stock. When the products are made to customer’s orders, the job of master schedule is largely to look out at the future work load of orders already on hand and seeing the date of delivery desired by the customer to fix the date of delivery i.e. one must know approximately, how many-hours work load is already there in each major department. It is also necessary to pay attention to the sequence of work loads in different departments. If an item needs to be designed, the engineering work load will have to come early. The development of a master schedule for manufacture to stock begins with a sales forecast. In such cases one of its major function is to smooth out the differences as much as possible between regular sales and steady production largely by inventories to cushion the differences.

(3) **Sequential Scheduling**: A best or optimum-schedule can rarely be recognised, even assuming the optimum to be known. Here the problem is to define a sequence for a multi-product plant which pass through a number of departments. If the sequence is varied in each department the number of sequences will increase and there is no known technique to identify the optimum sequence even assuming that the optimum can be explicitly defined.

(4) **Scheduling Devices**: Scheduling can be considered as a typical queuing problem with following criteria.
(i) each job joins the end of the queue with first in first out priority.
(ii) job with the longest duration always goes first.
(iii) jobs may be ranked according to earliest delivery date.

The schedules based on above criteria can be prepared with the help of following techniques:

1. Gantt Charts
2. CPM and PERT techniques

1. **Gantt Chart:** These charts portrays planned production and actual performance over a period of time for any or all of the factors that require planning and control. It is a rectangular chart divided by parallel horizontal and vertical lines.

   Some other type of charts viz. machine record charts showing the available machines and the time at which various jobs are planned, order charts indicating the time to start various orders and the time of completion can be used for scheduling.

2. **CPM and PERT Method:** Critical Path Method (CPM), Project Evaluation Review Techniques (PERT) based on network analysis have become powerful scheduling devices. Here job is first broken into basic elements and a network is constructed. The network is then analysed to prepare the schedule. These are discussed in section 4.2.

**Relationship between Routing and Scheduling:**

Both routing and scheduling are important techniques of production planning. Routing provides the best and the most economical production sequence, whereas, scheduling prepares a logical time-table showing the starting and finishing time of each production work in accordance with some predetermined programme.

**4.1.2 DISPATCHING AND LOADING**

**Dispatching:**

It is the transition from the planning to action phase. In this phase, the worker is ordered to start the work.
Loading:

In planning the production process, the management must know when a particular equipment/machine will be available for work on each order or item. For this information, a list of the number of machines capable of performing similar operations is prepared. Knowing the number of machines shifts available for each kind of operation and number of shifts required for such operations in the production process to complete the schedule, the planning staff can evaluate whether the work load is greater or less than the capacity of the equipment. This is done by loading.

Loading can be defined as the study of the relationship between load and capacity at the places where work is done. Loading and scheduling are designed to assist in the efficient and systematic planning of work. Loading provides a complete and correct information about the number of machines available and their operating characteristics such as speed, capacity, capability etc. This information can be used to calculate the difference between work load and actual capacity and then to determine whether customer’s order can be completed on the due date or not.

I. Objectives of Loading:

The following are some of the main objectives of loading:

(i) to plan new work orders on the basis of spare capacity available
(ii) to balance the work load in a plant
(iii) to maintain the delivery promises
(iv) to check the feasibility of production programmes

II. Loading Devices:

There are two main approaches for loading viz. loading step by step, and machine loading and load charts.

A. Loading Step by Step: Sometimes an individual production order may require a finite number of operations and the order of these operations may vary too much from item to item. In such cases overloads are scheduled to account for interaction among various operations by identifying the operation which imposes maximum delay on the order. Following are the steps in this approach:
(a) find the earliest date and the hours required that can be scheduled onto each operation
(b) determine the hours required at each operation and the time thereafter to complete the job if no loading delay occurs
(c) schedule the bottleneck operation as early as possible
(d) schedule subsequent operations as early as possible

B. **Machine Loading:** Using information from schedules, weekly periodic load in hours is determined for each machine and is then recorded on machine load chart.

The chart also gives the time for which the machine is busy for parts pertaining to different work orders.

A machine load chart for all the machines in a production department shows the future spare capacity of machines. The machine should be loaded to full capacities as idle capacities of machines are sources of loss to the organisation and also increase the cost of production.

C. **Load Charts:** Load charts shows the work assigned to various departments, machines or components of an organisation. During periods of peak/heavy loads information from load charts can be used to determine:

(i) priorities to future orders and to decide whether to subcontract or refuse new orders
(ii) provision of overtime or multishift operations
(iii) acquisition of extra men or equipment for additional capacity.

### 4.1.3 SEQUENCE ANALYSIS

Sequencing is the process of finding the order in which the jobs are to be processed at processing facilities such that some measure of performances are optimized.

There are three types of sequencing problems which are as listed below.

- Single machine scheduling
- Flow shop scheduling
- Job shop scheduling

In single machine scheduling, there will be n different jobs with single operation (the same operation). They require a single facility to process them. In this type of problem, any one or a combination of the following measures will be minimized.
- Mean flow time
- maximum lateness
- mean tardiness.

In flow shop scheduling problem, there will be n jobs with m different operations. But, the processing sequence of these jobs will be the same. In this type of problem, the objective is to minimize the makespan.

In job shop scheduling, there will be n different jobs with m operations in each. The process sequences of the jobs will differ from each other. This is the most complex problem. In this type of problem, the most famous objective is to minimize the makespan.

4.2 NETWORK ANALYSIS

4.2.1 Introduction:

All Organizations frequently engage in large, complex projects that require many different steps or operations to be performed in order to complete the project. The introduction of new product is a good example of a complex project, since it requires many operations, such as research and development, product testing, market research, and package design. In such cases job of planning and control of projects becomes difficult.

The concern of the managers involved with the implementation of the projects focuses around the question of when the project will be completed. Since many variables affect the time of completion of the project, it is important to have a decision making aid to assist in answering such questions as:

1. When do we expect to complete the project?
2. If any operation takes longer than expected, what effect will this have on overall completion time of the project?
3. What is the probability of completing the project by scheduled date?
4. If there are additional funds that can be spent to reduce the time to perform certain operations, how should they be spent?

CPM (critical path method) and PERT (project evaluation and review technique) are the two techniques used for planning and control project implementations and answer these questions.
CPM was developed in 1957 for scheduling construction activities.
PERT was developed in 1958 by US Navy, for the planning and control of the efforts involved in the development of submarines.

Both the techniques CPM and PERT were developed almost simultaneously by different organisations. The major difference between these two techniques is that CPM does not incorporate uncertainties in job times where as PERT allows probabilistic activity times. Today PERT and CPM are actually considered as one technique and difference if any are only historical. Consequently, both techniques will be referred to as project scheduling techniques.

Project scheduling by PERT-CPM consists of three basic phases: planning, scheduling and controlling.

The planning phase is initiated by breaking down the project into distinct activities. The time estimates for these activities are then determined and a network (arrow diagram) is constructed with each of its arcs (arrows) representing an activity. The entire arrow diagram gives a graphic representation of the inter dependence between the activities of the project. The construction of the arrow diagram as a planning phase has advantages of studying the different jobs in detail, perhaps suggesting improvement before the project is actually executed.

The objective of the scheduling phase is to construct a time chart showing the start and finish times for each activity as well as the relationship to other activities in the project. In addition, the schedule must pinpoint the critical activities that require special attention if the project is to be completed on time.

Finally the control phase uses the arrow diagram and time chart for making periodic progress reports. The network may thus be analysed and updated in the control phase.

4.2.1 Applications of CPM and PERT:
1. Construction projects (buildings, highways, bridges etc.)
2. Preparation of bids and proposals for large projects.
3. Maintenance planning of oil refineries.
5. Manufacture and assembly of large items such as airplanes, ships, and computers.

4.2.2 Fundamentals of CPM/PERT Networks:

A project can be viewed as a group of jobs or operations that are performed in a certain sequence to reach an objective. Each one of these jobs is usually referred to as an activity. Each activity consumes some time and resource. Also, each activity has a beginning and an end point that are points of time. These points in time are known as events.

The arrow diagram is used to represent the interdependencies and precedence relationships among the activities of the project. An arrow is used to represent an activity, with its head indicating the direction of progress. The precedence relationship between the activities is specified by using events. An event represents a point in time that signifies the completion time of some activities and the beginning of the new ones. The beginning and end points of an activity are thus described by two events usually known as head and tail events. Activities originating from a certain event cannot start until the activities terminating at the same event have been completed. In network theory terminology, each activity is represented by a directed arc and each event is represented by a node. The length of the arc need not be proportional to the duration of the activity. The Figure 4.1 (a) is an example of a typical representation of an activity (i, j) within as tail event and j as head event. Fig. 4.1 (b), is another example where activities (a, c) and (b, c) must be completed before activity (c, d) can start. The direction of progress in each activity is specified by assigning a smaller number to the tail event compared with the number of its head event. This procedure is especially convenient for automatic computations.

The following rules are applicable for the construction of the arrow diagram:

1. Each activity is represented by one and only one arrow in the network.

No single activity can be represented twice in the network. This is to be differentiated from the case where one activity is broken down into segments, in which case each segment may be represented by a separate arrow.
2. No two activities can be identified by the same head and tail events.

When two of more activities are performed concurrently such a situation may arise as shown in Fig 4.2 (a), where activities M and N have the same end events. The procedure is to introduce a dummy activity either between A and any one of the end events or between N and any one of the end events. The modified representation, after introducing the dummy X is shown in Fig 4.2 (b). Because of the introduction of this dummy activity, the activities M and N can be now identified by unique end events. It must be noted that a dummy activity does not consume any resource or time.

The dummy activities are also useful in establishing logical relationship in the arrow diagram that cannot otherwise be represented correctly. Suppose that in a certain project jobs A and B must precede C while job E is preceded by job B only. Figure 4.3 (a) gives the incorrect way since although the relationship among A, B and C is correct, the diagram implies that E must be preceded by both A and B. The correct representation using Dummy D is shown in Fig. 4.3 (b). Since D consumes no time the precedence relationship is also maintained.
4.2.3 Critical Path Calculations:

The application of PERT-CPM should ultimately yield a schedule specifying the start and completion dates of each activity. The arrow diagram represents the first step toward achieving that goal. Because of the interaction among the different activities, the determination of the start and completion times requires special computations. These calculations are performed directly on the arrow diagram using simple arithmetic. The end result is to classify the activities of the project as critical or non-critical. An activity is said to be critical if a delay in its start will cause a delay in the completion date of the entire project. A non-critical activity is such that the time between its earliest start and its latest completion dates (as allowed by the project) is longer than its actual duration. In this case the non-critical activity is said to have a slack or float time.

The advantage of pinpointing the critical activities and determining the floats will be discussed in Section 4.2.3.2. This section mainly presents the methods for obtaining this information.

4.2.3.1 Determination of the Critical Path:

A critical path defines a chain of critical activities that connects the start and end events of the arrow diagram. In other words, the critical path identifies all the critical activities of the project. The method of determining such a path is illustrated by a numerical example.

Example 4.1:

Consider the Fig. 4.4 that starts at node 0 and terminates at node 6. The time required to perform each activity is indicated on the arrows.

The critical path calculations include two phases. The first phase is called the forward pass, where calculations begin from the “start” node and move to the “end” node. At each node a number is computed representing the earliest occurrence time of the corresponding event. These numbers are shown in Fig. 4.4 in bottom of the two square boxes drawn near the node. The second phase, called the backward pass, begins calculations from the “end” node and moves to the “start” node. The number computed at each node is shown in top of the two square boxes drawn near the node.
Let $ES_i$ be the earliest start time of all the activities emanating from event $j$. Thus $ES_i$ represents the earliest occurrence time of event $i$. If $i = 0$ is the “start” event, then conventionally, for the critical path calculations, $ES_0 = 0$. Let $D_{ij}$ be the duration of the activity $(i, j)$, the forward pass calculations are thus obtained from the formula.

$$ES = \max (ES_i + D_{ij}), \text{ for all } (i, j) \text{ activities defined}$$

Where $ES_0 = 0$. Thus, to compute $ES_j$ for event $j$, $ES_i$ for the tail events of all the incoming activities $(i, j)$ must be computed first.

The forward pass calculations applied to Fig. 4.4 start with $ES_0 = 0$, as shown in the bottom square above event 0. Since there is only one incoming activity $(0, 1)$ to event 1 with $D_{01} = 2$,

$$ES_1 = ES_0 + D_{01} = 0 + 2 = 2$$

which is entered in the bottom square associated with event 1. Next, we consider event 2. (Notice that event 3 cannot be considered at this point, since $ES_2$ (event 2) is not yet known). Thus

$$ES_2 = ES_0 + D_{02} = 0 + 3 = 3$$
which is entered in the bottom square associated with event 2. The next event to be considered is 3. Since there are two incoming activities (1, 3) and (2, 3) we have

\[ ES_3 = \max (ES_i + D_{ij}) = \max (2+2, 3+3) = 6 \]

\[ i = 1, 2 \]

which is again entered in the bottom square of event 3.

The procedure continues in the same manner until ESj is computed for all j. Thus

\[ ES_4 = \max (ES_i + D_{ij}) = \max (3+2, 6+0) = 6 \]

\[ i = 2, 3 \]

\[ ES_5 = \max (ES_i + D_{ij}) = \max (6+3, 6+7) = 13 \]

\[ i = 3, 4 \]

\[ ES_6 = \max (ES_i + D_{ij}) = \max (6+2, 6+5, 13+6) = 19 \]

\[ i = 3, 4, 5 \]

These calculations complete the forward pass.

The backward pass starts from the “end” event. The objective of this phase is to compute LCi, the latest completion time for all the activities coming into event i. Thus, if i = n is the “end” event, LCn = ESn initiates the backward pass. In general, for any node i,

\[ LC_i = \min \{LC_j - D_{ij} \}, \text{for all (i, j) activities defined} \]

The values of LC (entered in the square) are determined as follows.

\[ LC_6 = ES_6 = 19 \]

\[ LC_5 = LC_6 - D_{56} = 19 - 6 = 13 \]

\[ LC_4 = \min \{LC_j - D_{4j} \} = \min \{13-7, 19-5\} = 6 \]

\[ j = 5, 6 \]

\[ LC_3 = \min \{LC_j - D_{3j} \} = \min \{6-0, 13-3, 19-2\} = 6 \]

\[ j = 4, 5, 6 \]
\[ LC_2 = \min \{LC_j - D_{2j}\} = \min \{6-3, 6-2\} = 3 \]
\[ j = 3, 4 \]

\[ LC_1 = LC_3 - D_{13} = 6 - 2 = 4 \]

\[ LC_0 = \min \{LC_j - D_{0j}\} = \min \{4-2, 3-3\} = 0 \]
\[ j = 1, 2 \]

The backward pass calculations are now complete.

The critical path activities can now be identified by using the results of the forward and backward passes. An activity \((i, j)\) lies on the critical path if it satisfies the following three conditions:

\[ ES_i = LC_i \quad (1) \]

\[ ES_j = LC_j \quad (2) \]

\[ ES_j - ES_i - LC_j - LC_i = D_{ij} \quad (3) \]

These conditions actually indicate that there is not float or slack time between earliest start (completion) and the latest start (completion) of the critical activity. In the arrow diagram these activities are characterized by the numbers in bottom and top squares being the same at each of the head and the tail events and that the different between the number in the two squares at the head event and the number in two squares at the tail event is equal to the duration of the activity.

Activities \((0,2), (2,3), (3,4), (4,5), \) and \((5,6)\) define the critical path in Fig. 4.4. Actually, the critical path represents the shortest duration needed to complete the project. Notice that activities \((2,4), (3,5), (3,6) \) and \((4,6)\) satisfy conditions (1) and (2) for critical activities but not condition (3). Hence they are not critical. Notice also that the critical path must form a chain of connected activities that spans the network from “start” to “end”.

**4.2.3.2 Determination of the Floats:**

Following the determination of the critical path, the floats for the non-critical activities must be computed. Naturally, a critical activity must have zero float. In fact this is the main reason it is critical.
Before showing how floats are determined, it is necessary to define two new times that are associated with each activity. These are the latest start (LS) and the earliest completion (EC) times, which are defined for activity \((i,j)\) by

\[
LS_{ij} = LC_j - D_{ij}
\]

\[
EC_{ij} = ES_i + D_{ij}
\]

There are two important types of floats: total float (TF) and free float (FF). The total float \(TF_{ij}\) for activity \((i,j)\) is the difference between the maximum time available to perform the activity \((LC_j - ES_j)\) and its duration \((D_{ij})\); that is,

\[
TF_{ij} = LC_j - ES_i - D_{ij}
\]

\[
TF_{ij} = LC_j - EC_{ij}
\]

\[
TF_{ij} = LS_{ij} - ES_i
\]

The free float is defined by assuming that all the activities start as early as possible. In this case \(FF_{ij}\) for activity \((i,j)\) is the excess of available time \((ES_j - ES_i)\) over its duration \((D_{ij})\); that is,

\[
FF_{ij} = ES_j - ES_i - D_{ij}
\]

The critical path calculations together with the floats for the non-critical activities can be summarized in the convenient form shown in Table 4-1. Columns (1), (2), (3), and (6) are obtained from the network calculations of example 4.2.1. The remaining information can be determined from the formulas given above.

Table 4-1 gives a typical summary of the critical path calculations. It includes all the information necessary to construct the time chart. Notice that a critical activity (marked *), and only a critical activity, must have zero total float. The free float must also be zero when the total float is zero. The converse is not true, however, in the sense that a non-critical activity may have zero free float. For example, in Table 4.1, the non-critical activity \((0,1)\) has zero free float.
Table 4-1

<table>
<thead>
<tr>
<th>Activity</th>
<th>Duration</th>
<th>Earliest</th>
<th>Latest</th>
<th>Total float</th>
<th>Free float</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i,j)</td>
<td>D&lt;sub&gt;j&lt;/sub&gt;</td>
<td>ES&lt;sub&gt;i&lt;/sub&gt;</td>
<td>E&lt;sub&gt;j&lt;/sub&gt;</td>
<td>LS&lt;sub&gt;j&lt;/sub&gt;</td>
<td>LC&lt;sub&gt;j&lt;/sub&gt;</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>(0,1)</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>(0,2)</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>(1,3)</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>(2,3)</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>(2,4)</td>
<td>0</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>(3,4)</td>
<td>3</td>
<td>6</td>
<td>9</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>(3,5)</td>
<td>2</td>
<td>6</td>
<td>8</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>(3,6)</td>
<td>7</td>
<td>6</td>
<td>13</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>(4,5)</td>
<td>5</td>
<td>6</td>
<td>11</td>
<td>14</td>
<td>19</td>
</tr>
<tr>
<td>(5,6)</td>
<td>6</td>
<td>13</td>
<td>19</td>
<td>13</td>
<td>19</td>
</tr>
</tbody>
</table>

The roles of the total and free floats in scheduling non-critical activities is explained in terms of two general rules:

1. If the total float equals the free float, the non-critical activity can be scheduled anywhere between its earliest start and latest completion times.

2. If the free float is less than the total float, the starting of the non-critical activity can be delayed relative to its earliest start time by no more than the amount of its free float without affecting the scheduling of its immediately succeeding activities.

4.3 PERT COMPUTATIONS:

As mentioned earlier in this chapter, the major difference between PERT and CPM is the manner in which the activity times are expressed. In CPM calculations discussed above, the activity times are given as constant.
In PERT the activity times are described by a probability distribution rather than a single estimate so that the uncertainty associated with the project timings can be adjusted.

The originators of PERT were faced with the problem of finding a particular kind of probability distribution; they wanted the a distribution of activity times with four characteristics as given below:

1. A small probability (1 in 100) of reaching the most optimistic time (shortest time) symbolised by ‘a’.
2. A small probability (1 in 100) of reaching the most pessimistic time (longer time) symbolised by ‘b’.
3. Only one most likely time which would be free to move between the two extremes mentioned in 1 and 2, symbolised by ‘m’.
4. The ability to measure the uncertainty in estimating.

![Diagram showing the distribution with most optimistic, most likely, and most pessimistic times]

**Fig 4.5**

The beta distribution was found to have all the above four characteristics as shown in Fig 4.5.

After these timings are estimated, they are combined into a single workable time estimate using weighted average as follows:

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

where \( t \) equals to the expected time of the activity.
To describe the variation or dispersion in the activity times in PERT networks, we use standard deviation for that activity. The difference between the 'a' time and 'b' time represents the distance from the extreme left hand end and the extreme right hand end of the distribution of possible activity times. The distance is about plus or minus 3 standard deviations.

Therefore \[ b - a = 6 \]

Thus 1 standard deviation = \[ \frac{b - a}{6} \]

and variance = \[ \left( \frac{b - a}{6} \right)^2 \]

Finding Critical path in PERT networks:

In PERT network for each activity three viz 'a', 'b' and 'm' are specified. Using these three time estimates the mean time for an activity can be computed using the formula

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

Once this \( t \) is computed the for all the activities, we get a single time estimate for activities. Using this single time and following the procedure explained for CPM calculations, the critical path can be found out.

**Example 4.2:**

Consider the project of example 4.1. To avoid repeating the critical path calculations, the values of \( a, b \) and \( m \) shown in table 4.2 are selected in such a manner the \( t_{ij} \) will have the same values as its corresponding \( t_i \) in example 4.1. The mean \( t_{ij} \) and variance \( v_{ij} \) for all the activities are given in the table 4.2
Table 4.2

<table>
<thead>
<tr>
<th>Activity</th>
<th>Most optimistic time (a)</th>
<th>Most pessimistic time (b)</th>
<th>Most likely time (m)</th>
<th>Mean time</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>1.0</td>
<td>3.0</td>
<td>2.0</td>
<td>2.0</td>
<td>0.11</td>
</tr>
<tr>
<td>0-2</td>
<td>2.0</td>
<td>8.0</td>
<td>2.0</td>
<td>3.0</td>
<td>1.00</td>
</tr>
<tr>
<td>1-3</td>
<td>1.0</td>
<td>3.0</td>
<td>2.0</td>
<td>2.0</td>
<td>0.11</td>
</tr>
<tr>
<td>2-3</td>
<td>1.0</td>
<td>11.0</td>
<td>1.5</td>
<td>3.0</td>
<td>2.78</td>
</tr>
<tr>
<td>2-4</td>
<td>0.5</td>
<td>0.75</td>
<td>1.0</td>
<td>2.0</td>
<td>1.36</td>
</tr>
<tr>
<td>3-4</td>
<td>Dummy activity</td>
<td></td>
<td></td>
<td>0.0</td>
<td>0.00</td>
</tr>
<tr>
<td>3-5</td>
<td>1.0</td>
<td>7.0</td>
<td>2.5</td>
<td>3.0</td>
<td>1.00</td>
</tr>
<tr>
<td>3-6</td>
<td>1.0</td>
<td>3.0</td>
<td>2.0</td>
<td>2.0</td>
<td>0.11</td>
</tr>
<tr>
<td>4-5</td>
<td>6.0</td>
<td>8.0</td>
<td>7.0</td>
<td>7.0</td>
<td>0.11</td>
</tr>
<tr>
<td>4-6</td>
<td>3.0</td>
<td>11.0</td>
<td>4.0</td>
<td>5.0</td>
<td>1.78</td>
</tr>
<tr>
<td>5-6</td>
<td>4.0</td>
<td>8.0</td>
<td>6.0</td>
<td>6.0</td>
<td>0.44</td>
</tr>
</tbody>
</table>

PROBABILITY ESTIMATES OF PERT:

For the purpose of computation of critical path the activity times have been considered as constant. Let us now examine the effect of uncertainty in estimating process on completion dates. Here the critical path is 0-2-3-4-5-6 and the expected total project time is 19. In the above table we have computed the variance for each activity. Now the variance of the project completion time is given by the summation of variance of the critical activities as follows:

\[ \text{var} = \text{var of (0-2)} + \text{var of (2-3)} + \text{var of (3-4)} + \text{var of (4-5)} + \text{var of (5-6)} \]
\[ = 1 + 2.78 + 0 + 0.11 + 0.44 \]
\[ = 4.33 \]

Suppose it is required to find out the probability of completing the project in 'X' days
\[ p = \frac{x - \text{mean project completion time}}{\text{variance of the project completion time}} \]

Looking into the normal table for value of ‘p’ gives the probability of completing the project in \( X \) days.

**Example 4.3:**

Probability of completing the project in 20 days is given by

\[ p = \frac{20 - 19}{4.33} = 0.2309 \]

Referring to the Normal table it can be found that 0.2309 gives a probability of 59%. Hence it can be concluded that the project can be completed in 20 days with a probability of 59%.

**QUESTIONS**

1. Explain routing.
2. What are the advantages of routing?
3. What are the objectives of scheduling?
4. Discuss the classification of schedule.
5. Distinguish between CPM and PERT.
6. Define dispatching and loading.
7. Explain different loading methods.
8. List various application areas of CPM & PERT.
9. Consider the following Project:

<table>
<thead>
<tr>
<th>Activity Predecessor</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Duration (Days)</td>
<td>15</td>
<td>12</td>
<td>7</td>
<td>34</td>
<td>28</td>
<td>18</td>
<td>14</td>
</tr>
</tbody>
</table>

a) Construct the network.
b) compute the project completion time
c) determine the critical path and
d) compute the floats.
10. The following are the activities involved in the preparation of the next year's budget for a company. Prepare a network model and carry out the critical path computations:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
<th>Predecessors</th>
<th>Duration (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Forecast Sales Volume</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>B</td>
<td>Study Competitive Market</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td>C</td>
<td>Design Item &amp; Facilities</td>
<td>A</td>
<td>5</td>
</tr>
<tr>
<td>D</td>
<td>Prepare Production Schedule</td>
<td>C</td>
<td>3</td>
</tr>
<tr>
<td>E</td>
<td>Estimate Cost of Production</td>
<td>D</td>
<td>2</td>
</tr>
<tr>
<td>F</td>
<td>Set Sales Price</td>
<td>B,E</td>
<td>1</td>
</tr>
<tr>
<td>G</td>
<td>Prepare Budget</td>
<td>E,F</td>
<td>14</td>
</tr>
</tbody>
</table>

11. The following are the time estimates \((a, b, m)\) for a Project:

<table>
<thead>
<tr>
<th>Activity</th>
<th>1-2</th>
<th>1-4</th>
<th>1-5</th>
<th>2-3</th>
<th>2-5</th>
<th>2-6</th>
<th>3-4</th>
<th>3-6</th>
<th>4-6</th>
<th>4-7</th>
<th>5-6</th>
<th>5-7</th>
<th>6-7</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>7</td>
<td>8</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>9</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>b</td>
<td>8</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>10</td>
<td>13</td>
<td>10</td>
<td>5</td>
<td>10</td>
<td>8</td>
<td>15</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>m</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>4</td>
<td>8</td>
<td>6</td>
<td>10</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

a) Draw the network and determine the expected project completion time.

b) Determine the probability of completing the project in 28 days.
UNIT - V

Lesson 5.1.

MATERIALS MANAGEMENT

OBJECTIVES:

This lesson aims to bring to your attention, the function of Materials Management and aids you to develop a basic understanding of this function and to appreciate its role in a manufacturing organization.

5.1.1. INTRODUCTION

In the process of manufacturing, adequate materials, components, supplies, equipment and services are essential. These basic necessities not only must be available in the required amounts, but also must be of the “right” quality and at the “right” total cost. To prevent delays or work stoppages, these essentials must also be accessible at desired locations and at the “right” time. Meeting these basic needs is the responsibility of Materials Management.

Especially in manufacturing organizations, Materials Management assumes greater importance, though it also adds to the greater degree of complexities. The “value added” by the manufacturer is the margin between raw materials and the finished products. This margin represents the unique contribution made by the manufacturing organization through the business operations like, the flow of materials from supplier plants, through the manufacturing process, into finished goods warehouses and on to the ultimate user of the product. These operations fall into a broader description of Materials Management. Due to such a strategic role, the Materials Management has assumed greater importance in the modern management.

5.1.2. DEFINITION OF MATERIALS MANAGEMENT

Materials Management is the planning, directing, controlling and coordination of those activities concerned with material and inventory requirements from the point of their inception to their introduction into the manufacturing process. It begins with the determination of material quality
and quantity, and ends with its issuance to the production in time to meet customers’ demands on schedule and at the lowest costs.

According to Dean S. Ammer, the Materials Management would embrace all activities concerned with materials except those directly concerned with designing or manufacturing the product or maintaining the facilities, equipment and tooling. It would embrace the activities performed by major departments such as purchasing, production control, receiving and inspection, stores, traffic and physical distribution.

According to Lamar Lee and Donald Dobler, Materials Management refers to an integrated management approach to planning, acquisition, conversion, flow and distribution of “production materials” from the raw-material state to the finished-product state.

The Materials Management concept brings together all the many and varied activities that impinge on the flow of materials through the firm and places them under the direct supervision of one individual: the Materials Manager. Depending on the size of the firm, these activities may include: purchasing, traffic, expediting, production control, inventory management, receiving, storage, shipping, materials handling, quality control, scrap and salvage and vendor evaluation and purchasing.

5.1.3. OBJECTIVES OF MATERIALS MANAGEMENT

The objectives of Materials Management are projected from the top management through the Materials Manager. Sometimes the Materials Manager himself sets the objectives in line with the corporate policy. Materials Management, being an important service function in a manufacturing organization, should try to provide the efficient service at least cost. This can be achieved through the attainment of the following objectives:

1. **Procurement of materials at low cost**: Direct material cost comprises more than 50% of the total product cost. A slightest saving in the materials cost ensures substantial monetary advantage resulting in enhanced profit margin or competitive strength.

2. **High rate of inventory turnover**: High rate of inventory turnover contributes to the profitability and enhances the liquidity of current assets.
3. **To ensure continuity of supply:** The lack of continuity of supply of materials disrupts the production flow and thus increases the operating cost and incidence of overheads on the unit of production.

4. **To maintain the consistency of quality:** Materials Management endeavours to know the specific requirements of the materials and services needed by the manufacturing departments. The procurement is then managed according to the precise specifications.

5. **To minimize the acquisition and storing cost:** It involves the incidental costs such as ordering cost, inward freight charges, receiving and inspection cost, storing cost, etc. On an average, this represents more than 10% of the value of the materials and any saving in it increases the profit margin of the company.

6. **Lower administrative cost:** The establishment of Materials Management department involves pay roll and such other incidental administrative costs. Such costs should be reduced to the minimum and its benefits must outweigh the cost of creating such organization.

7. **Maintenance of supplier relations:** It helps in evolving a favourable image in the business circles and avails certain indirect economic advantages such as reasonable price, preference in shortage, intimation about forthcoming shortages, at times prolonged payments in bad days, etc.

8. **Development of new materials and new sources:** The purchase research helps in exploring the new sources of supply. This may avail the better quality of materials at favourable terms.

9. **Efficient record-keeping and prompt reporting:** Materials Management involves huge paper work. Efficient record maintenance and prompt reporting of key information improves the quality of decisions. One way of doing this is to use computers for this purpose.

10. **Development of Personnel:** This will build capable and creative personnel, helping them to grow in the organization and also in building a contented employee force in the organization.

The objectives of Materials Management are not only varied but they are conflicting also. As a result, the attainment of one objective can be had only at the cost of the other. Under such situations, the priorities may be assigned to a specific objective out of the given set of objectives, according to the timely need of the organization.
5.1.4. SCOPE OF MATERIALS MANAGEMENT

The Materials Management function within its ambit, includes the following activities:

a) **Materials planning** - This planning part of the Materials Management deals with issues like translation of the sales projections into long-term material requirements, project the facilities required for the materials management.

b) **Production control** - It develops the short-range operations plan and schedules from the long-range plans. It directs and regulates the orderly movement of materials through the entire manufacturing cycle, with minimum inventory investment and maximum manufacturing efficiency.

c) **Inventory control** - This is a systematic procedure for ensuring the availability of items necessary to meet the production requirements at optimum cost.

d) **Purchasing function** - Its basic objective is to procure the materials of desired quality in time to meet the production specifications and at the lowest ultimate cost.

c) **Receiving and inspection** - The main activities here, are to accept the delivery of purchased material, to verify them with the purchase order and packing slip, to inspect them and to prepare the goods received note for stores and accounts, and to route the received materials to stores or to the using department according to the direction of the order.

f) **Store-keeping** - This section stores the materials properly, ensuring quick identification and periodic verification, and issues the materials according to authorised requisitions.

g) **Shipping** - This function is concerned with the distribution of the finished goods.

h) **Material handling** - Though this function is sometimes grouped with the Stores function, it, as a distinct service, involves handling in-plant materials and maintaining material handling equipment.

i) **Traffic** - It is concerned with the incoming consignments of raw materials and outgoing shipments of finished goods, and also maintaining its own traffic fleet or administering freight rates, routes, etc.
j) **Physical distribution** - The process of moving the finished goods to the ultimate consumer is termed as physical distribution. The traffic function is sometimes clubbed with the physical distribution when the shipment and storage of finished goods are costlier.

### 5.1.5. ADVANTAGES OF MATERIALS MANAGEMENT

By implementing the Materials Management concept, an organization may obtain many benefits that are not otherwise possible. These benefits can be listed out as below.

1. Provides better coordination of time and effort in meeting the material needs of the firm.
2. Accountability for performance is no longer fragmented among departments, but rests on the Materials Manager.
3. Materials Management as a separate operational unit, eliminates overlapping or conflicting authority and responsibility, thereby forging smoother working relations.
4. Reduction in levels of inventory and greater flexibility to prevent delays and shortages of materials.
5. Lower handling costs through better routing of shipments and in-plant movement of goods.
6. Workers' wider perceptions of the firm's operation, resulting in greater efficiency.
7. Better vendor relations, which result in smoother production and reduced production costs.

### 5.1.6. SUMMARY

The broader definition of Materials Management combines, under a separate function, all activities concerned with the orderly flow of raw materials, components, operating supplies and finished goods. Raw materials are obtained from vendors, made available for production, stored as finished goods and finally distributed in accordance with customer wants. There is a Materials Manager who supervises and is responsible for purchasing, inventory management, production control, receiving, storage, shipping, surplus and scrap disposal, expediting and quality control. By implementing the concept of Materials Management, an organization can obtain many benefits contributing to improved profitability and productivity of the firm.
5.1.7. SUGGESTED READINGS


QUESTIONS

1. What is meant by the Materials Management concept?
2. What activities are usually included as part of the Materials Management function?
3. Explain the scope of Materials Management in a manufacturing firm.
4. Discuss the advantages that a firm may expect as a result of implementing the Materials Management concept.
OBJECTIVES:

This lesson attempts to present the "purchasing" function in an organization as a core activity in Materials Management. By describing the purchasing objectives, procedure and methods, the lesson will enable you to gain a managerial insight into this function, which is vital for a successful Materials Manager.

5.2.1. INTRODUCTION

Purchasing is narrowly described as "the process of buying". However, in a broader sense, the term involves determining need, selecting the supplier, arriving at proper prices, terms and conditions, issuing the contract or order, and following-up to ensure proper delivery. In simple terms, the basic elements involved in performing the purchasing function include obtaining the proper equipment, material, supplies and services in the right quality, in the right quantity, at the right time, at the right price, and from the right source.

Purchasing can be broadly classified into two groups, viz., mercantile purchasing and industrial purchasing. Mercantile purchasing refers to the commercial activities wherein the buying of items is intended to their resale at a profit. Industrial purchasing involves the procurement of items for the purpose of consumption or conversion, that is, it deals with the efficient procurement and management of issues incidental to it in respect of the items like raw materials, components, consumable stores and supplies, office supplies and appliances, spares and tools, and machines and equipments. This lesson primarily analyses the issues involved in industrial purchasing.

5.2.2. OBJECTIVES OF PURCHASING

Purchasing, being an inevitable activity of any business, is recognized by the progressive organizations to the extent of setting up a separate purchase department to look after this function. The objectives of the purchase function
must be spelt out clearly for the justification of its independent existence. They must be in conformity with the overall objectives of the organization.

The basic objective of the purchasing function is to ensure continuity of supply of materials and at the same time reduce the ultimate cost of the finished goods. This means, the objective is not so much to procure the cheapest materials but to reduce the cost of the final product. For ensuring this, there are a large number of well known parameters such as right price, right quantity, right contractual terms, right time, right source, right material, right place, right mode of transportation, right quality and right attitude. These purchase parameters are summed up in Figure 5.1.

![Diagram of Purchase Parameters]

**Fig. 5.1. Purchase Parameters**

The overall objectives of the purchase department can be outlined as follows:

1. To buy at the lowest possible prices.
2. To have a high inventory turnover, thereby diminishing excess storage, carrying expenses and inventory losses as a result of deterioration, obsolescence and pilferage.
Step-2. **Review by Head of using department:** This intra-departmental step, requires the purchase requisition to be forwarded to the head of the using department, who scrutinizes it for its accuracy and approves the need or questions unusual requirements. He may be advised of company policies which might influence his approval.

Step-3. **Comparison with Purchase budget:** Assuming that the purchase requisition has been approved by the head of the originating department, a copy is then forwarded to the Finance department for checking against the Purchase budget. It is screened for two basic considerations, viz., whether the request for an item is within the current allotment for that class of materials and whether the request exceeds the total budget allocation for the concerned department. If these conditions are met, the Purchase requisition is forwarded to the Purchasing department for appropriate action.

Step-4. **Attachment of commodity purchase record:** A record of previous purchases of the commodity is attached to the purchase requisition to facilitate the screening function of the Purchasing department.

Step-5. **Examination by Purchasing department:** The Purchasing department, now holding the Purchase requisition, has the responsibility to examine it, compare it with previous purchases, analyze it in relation to current requirements and take appropriate action to fulfill the request, taking into consideration company policies and standard operating procedures of the Purchasing department.

Step-6. **Issuance of bid (Request for Quotation):** The Purchasing department maintains a record of acceptable vendors. (The criteria of acceptability include a favourable record of experience in dealing with the vendor in the past, approval of the vendor's facilities, location, quality of products, services and guarantees, prices, terms and availability; as well as reputation and financial standing. Many purchases are repetitive transactions with the same vendor and hence only the price may have to be negotiated. Where a doubt arises concerning the right price to be paid, a request for quotations is made. This is sent to all firms on a list of screened vendors. When quotations are received from vendors, they must be held in confidence.

Step-7. **Selection of vendor and placement of order:** Bids are opened at the specified time. Although the lowest bidder is generally
given the order, this is not always the case since so many qualitative considerations also play a major part in selecting the vendor. The successful vendor is notified of the award by receipt of a Purchase order. The Purchase order is prepared from the requisition and the additional information previously described.

**Step-8. Follow-up and expediting:** It might be necessary to pressurise the supplier by visit, mail, telephone or telegraph to ensure that materials are delivered on time. Close material scheduling is extremely important to efficient production. Therefore, follow-up responsibility and the mission of expediting is essential to prevent shortages.

**Step-9. Receipt of goods:** The receiving department receives deliveries and communicates with the appropriate departments concerning the arrival of the incoming goods. It is also charged with the responsibility of checking (generally against the Purchase order) the vendor, order number, description of materials or services, quantity, time of arrival and department for which the goods are destined. The defective goods are returned to the vendor with a relevant explanation. The vendor must be notified whether the buyer wishes to have the defective material replaced or to cancel the order, in accordance with the contractual agreement.

**Step-10. Receipt into storage/stores:** Received goods must be sent to storage. The functions of the Stores section encompasses materials handling, storage, protection, maintenance and issuance of goods.

**Step-11. Performance of supplementary functions:** Additional steps can supplement those cited. Thus it is essential for Accounts function to check a vendor’s invoice against a copy of the order before certifying it for payment. Purchasing must observe and record the results of the use of the commodities or services purchased, maintain suitable purchase records, predict potential needs and co-operate with other departments, for example, in recommending the most suitable materials, supplies and equipment.

**Step-12. Shipment of end-products and disposal of unwanted materials:** The last step in the Purchasing procedure is shipping the firm’s products to its customers and the disposition of unwanted material. The Traffic department makes provision for packing and shipment in accordance with customer requests. For the disposal of unwanted materials, such as scrap, surplus and waste,
the Traffic department assists the Purchasing department in arranging for the movement of the goods to the site designated by the buying firm.

5.2.4. CENTRALIZED AND DECENTRALIZED PURCHASING

A basic Organization decision that each firm must take is whether or not to centralize all purchasing. This decision is concerning the purchasing policies defining the purchasing authorities and the resultant responsibilities. The following conditions may be useful as a guide in making the decision to centralize or decentralize the purchasing function:

1. The long-range plan of the Organization
2. The organizational pattern of the firm which indicates either a highly centralized or decentralized operation
3. The similarity or dissimilarity of products produced at various plant locations
4. The extent of geographical dispersion of plants
5. The size of the firm and volume of purchases of specific materials and components

Centralized purchasing is a method of procurement of all types of materials, supplies, equipments, etc. through a single department (not necessarily centrally located) under the direct control and superintendence of one responsible person. He is directly accountable to the Top management for all duties falling within the broad area of Purchase function. Though centralization avails certain advantages (discussed in the later part of this section), a certain degree of decentralization is desirable under the following conditions:

a) Where the unit uses single natural raw material which is available at local markets, it is desirable to have decentralized buying. The prices of such commodities fluctuates at various markets, the grades differ as per the localized climatic conditions, the deals are completed through auction in local markets.

b) Sometimes certain low-value technical items are obtained from local vendor. The buyer has to keep himself in close touch with the vendor.

c) The purchase of certain non-technical odd items are allowed to be purchased from local markets. The reason is that the cost of paper
processing from placing an order sometimes exceeds the cost of such items.

d) Partial decentralization of Purchase function would be highly desirable in a scattered multi-plant unit manufacturing diversified products.

Centralization of Purchases offers many advantages. They are listed below:

1. As the duplication of efforts in buying function is eliminated, its cost will be relatively less and it will be managed efficiently.
2. The Heads of other departments are relieved from the responsibility of purchasing their own requirements. They can concentrate in their assigned areas of activities.
3. It is possible to tap the advantage of the specialized skill of the buying staff.
4. Bulk buying strengthens the bargaining position of the buyer. Also, the advantage of quantity discount can be tapped.
5. It enables to develop and maintain good relations with the suppliers.
6. It will enable the purchase of standardized items through standardized procedure.
7. It will reduce the inventory carrying costs, when the central buying staff manage the stock levels, recording material usage, lead time and prices effectively.
8. The receiving of large supply through consolidated orders reduces the transport cost per unit.
9. The cost of order processing is reduced substantially due to few orders, but of large quantities.
10. From a management viewpoint, centralized purchasing makes Top management's experience and advice readily available. The Purchase Manager can offer assistance to other departments and to Top management, for example, in forecasting market trends and general business conditions.

The Centralized purchasing suffers from the following limitations:

1. The specific requirements of the individual items may not be attended successfully. At times, it may result in the absence of matching of mind between the needy section and the buying section resulting in wrong buying.
2. The Centralized standard procedure may result in delays in receiving the materials.
3. It is likely that the centralized buying staff may not be expert in buying varied types of items.

4. In case of multi-plant units located at distant places and receiving their requirements from centralized storing, it may not be possible to tap the local resources.

A number of companies utilize the best features of both the approaches - Centralized and Decentralized purchasing.

5.2.5. SPECIALIZED PURCHASING METHODS

The material requirements of a firm are broadly classified into two, namely, direct materials and indirect materials. The Purchase procedure discussed in the earlier section deals with the purchase of direct materials. For indirect materials like stores, supplies and maintenance, it is desirable to have certain specialized Purchasing procedures to make advantage of the nature of these materials and also the time and cost considerations. The following are certain specialized Purchasing procedures:

1. **Blanket orders**: The blanket order is a type of standing order with the supplier for the supply of the materials according to the requirements of the buyer. The deliveries are scattered over the contractual period, which is usually one year. The blanket order procedure is advisable for materials of low value but having a high annual usage, the rate of usage of which cannot be planned precisely.

2. **Stockless purchasing**: As the name indicates, the buyer is not required to maintain the stock of these items. The onus of the maintenance of the stock rests with the supplier. The supplier locates the materials at his own plant or at buyer's plant. When the materials are located at buyer's plant, it is known as "Consignment buying". The buyer identifies the materials to be obtained under such arrangement. They are properly described and clubbed into related groups along with their rate of usage. Negotiations are made with the supplier accordingly. Generally, the price of the materials is a bit higher than the usual price because the storing and carrying costs are borne by the supplier.

3. **Systems contracting**: It incorporates the characteristics of blanket contract (in that a periodic contract is made with the vendor) and stockless buying (in that the buyer is not required to maintain the safety-stock). But the Systems contract is unique in the sense that it is a long-term contract as compared to other arrangements. It assists
the buyer and seller to improve re-ordering of repetitive-use materials or services with an absolute minimum of administrative expense and with the maintenance of adequate business controls.

4. **Small order purchases**: It is a common experience of all firms that they need certain items of non-recurring nature which involve very insignificant cost. Such items are purchased without undergoing the formal purchase procedure. Such purchases are known as "paperless purchasing". The popular methods of such purchases are:
   
a) Purchases under the petty-cash system where indirect cash purchases are for small items
   
b) Purchasing through telephone orders wherein no formal purchase orders are sent to the supplier
   
c) Purchasing under the Cash-on-delivery system wherein the purchases of certain major items are made on cash basis.

**5.2.6. SUMMARY**

Purchasing, in business terms, is the acquisition of the most advantageous quantities of materials needed for operations and their delivery at the right time, at the lowest price, with desired terms. While purchasing procedure varies greatly from one firm to another, certain steps are fundamental. The Purchasing department may be organized on the basis of buying policy. Centralized purchasing is done through a single purchasing office; decentralized purchasing is performed by various departments (in geographically separate plants) to cater to their own material needs. Combinations and variations of these methods are extensively used in the business world. In the case of buying standardized indirect materials (such as stores and supplies) certain specialized Purchasing procedures are employed.

**5.2.7. SUGGESTED READINGS**

QUESTIONS

1. Discuss the objectives of the Purchasing function.
2. Why there is no ideal organization for the Purchasing department that will be suitable for all firms?
3. Compare the advantages and the disadvantages of Centralized and De-centralized Purchasing.
4. What are the criteria used by the Buyer in selecting the “right” vendor?
5. What is Purchasing procedure? Explain the steps involved in it.
6. Write short notes on the following:
   a) Blanket order
   b) Stockless buying
   c) Systems contracting
   d) Small order purchases
Lesson 5.3.

STORE-KEEPING

OBJECTIVES:

This lesson has been written with the aim of helping you to understand the Stores function in a firm and appreciate its role and purpose in the organization from a Manager's viewpoint.

5.3.1. PURPOSE OF STORES

Stores is a service function in a firm. In stores room, the inventories - raw materials, work-in-progress, finished goods, bought-out components, consumable stores, spares and scraps are stored. The most important service by the stores is to provide uninterrupted service to the user departments, with which stores is in direct contact. Stores is often equated directly with money, as money is locked up in the stores in the form of inventories. The functions of stores can be classified as follows:

1. To receive raw materials, components, tools, equipments and other items and account for them.
2. To provide adequate and proper storage and preservation to the various items.
3. To meet the demands of the consuming departments by proper issues and account for the consumption.
4. To minimize obsolescence, surplus and scrap through proper codification, preservation and handling.
5. To highlight stock accumulation, discrepancies and abnormal consumption and effect control measures.
6. To ensure good housekeeping so that material handling, material preservation, stocking, receipt and issue can be done adequately.
7. To assist in verification and provide supporting information for effective purchase action.
5.3.2. STORE LOCATION AND LAYOUT

The store-room is commonly described as a "place for everything and everything at its place". The first part of the phrase refers to the provisions of adequate space for the materials while the latter part highlights on the scientific location and layout of the store-room. The store-room space may be in the form of constructed buildings or godowns, temporary structures or even in the form of vast open yards. The size and type of storage space is dependent on varied factors such as the number of items to be stored, quantity, material characteristics such as liquid, fragile, weight, dimension, cost, chances of evaporation, etc. While deciding the storage space, due consideration should also be given to the space required for the movement of material-handling equipment inside the store area. The basic principles of stores location are: straight-line movement with minimum of backtracking, minimization of handling, re-handling and internal transportation costs, minimization of waste motion for personnel and reduced human hazards, efficient utilization of storage space and provision for the flexibility and expansion of the store-area.

The stores location will differ according to the divisibility of the total storage space, type of business activity (say, multi-product operations), manufacturing operations carried-on at multi-plants located at distant places, type of production processes such as continuous processing, job-order production, assembling, etc. Fundamentally, the raw-materials should be stored in the vicinity of the starting point of the production operation, work-in-progress materials between first and following operations, finished inventories near the shipping area, and spares, tools and stores somewhere in the central storage area.

5.3.3. ADVANTAGES OF STORE-KEEPING

The materials are stored at one central godown or in the godowns located at distant places. When the materials are stored in distantly located godowns, receiving materials from various suppliers and issuing materials to remotely located production centres appear less cost-effective and more troublesome. The problem of Centralized storing versus Decentralized one should be decided on the basis of their under-mentioned relative merits and demerits which
are mutually exclusive in nature. The merit-list for Centralized storing is as follows:

1. Bulk buying in few orders with the advantage of quantity discount and transportation cost.
2. Possibility of standardization of materials reducing the variety of items stored.
3. Reduced investments in inventories.
4. Reduction in administrative cost.
5. Reduction in the requirements of the personnel.
6. Reduced storage space and other incidental expenses.
7. Greater safeguard against pilferage and theft.

The demerits of centralized storing are:

1. Increase in the material handling cost.
2. Possibility of bottlenecks and the resultant delays.
3. Possibility of communication gap between the user of the item and its supplier.
4. In the absence of proper designing of the routine work, the administrative cost may go up.
5. Greater danger of loss by fire.

5.3.4. STORE-KEEPER’S RESPONSIBILITIES

A Store-keeper has a triple responsibility. First of all, he is responsible primarily to Maintenance or Engineering department for having the right items on hand when they are needed, so that the Maintenance department can keep the plant running with a minimum down-time. He cannot avoid all stockouts, but should take his calculated risks where they will do the least damage. Secondly, he must work closely with Purchasing, telling them what to order, when and how much. Thirdly, he is responsible to the Financial people for the accuracy of his records, the size of the inventory and the economy and efficiency of his operation.

5.3.5. SUMMARY

Stores play a vital role in the operations of a firm. It is in direct contact with the user departments in its day-to-day activities. Being a service function,
Stores provide an economic service to maintain the value of the stores in terms of stock at the lowest possible level and to make the required inventory available at all times. In stores layout, the governing criteria are easy movement of materials, good housekeeping, sufficient space for men and material handling equipments, optimum utilization of storage space and judicious use of storage equipments. Factors governing stores location are the number of end users and their location, the volume and the variety of goods to be handled, the location of the central receiving section and accessibility to modes of transportation such as rail or road. A store-keeper is responsible for the efficient operation of the Stores.

5.3.6. SUGGESTED READINGS


QUESTIONS

1. What is Store-keeping? Justify its existence as a separate entity.
2. Discuss the location and layout aspects in setting-up a Store.
3. Compare and contrast between Centralized and De-centralized storing.
4. What are the responsibilities of a Store-keeper?
UNIT - VI
Lesson 6.1.

INVENTORY MANAGEMENT

OBJECTIVES:

This introductory lesson on inventory management has been presented so as to give you a fresh insight into this inventory function and its significant role in a manufacturing firm. You will also be able to classify the inventories into different categories and identify the costs associated with them, after reading this lesson.

6.1.1. INTRODUCTION

Inventories may constitute the largest component of current assets in many organizations. They are maintained basically for the operational smoothness which they can effect by uncoupling successive stages of production, whereas the monetary value of inventory serves as a guide to indicate the size of the investment made to achieve this operational convenience. Poor management of inventories therefore may result in business failures. A stock-out creates an unpleasant situation for the organization. Conversely, if a firm carries excessive inventories, the added carrying cost may represent the difference between profit and loss. Efficient inventory control, therefore, can significantly contribute to the overall profit-position of the organization. Control over inventories, their quantity, quality and storage, is a primary concern of the Purchasing department and of major interest to the Top management.

6.1.2. FUNCTIONS OF INVENTORIES

There are five basic types of inventory functions, as discussed below:

1. Fluctuation inventories: These inventories are carried because the quantity and timing of sales and production cannot be predicted accurately. These fluctuations in demand and supply may be covered by reserve stock or safety stock. Fluctuation inventories exist in work
centres when the flow of work through these centres cannot be completely balanced. Fluctuation inventories, also called as stabilization inventories, may be provided in the production plan so that production levels do not have to change in order to meet random variations in demand.

2. **Anticipation inventories:** These are inventories built-up in advance of a peak selling season, a marketing promotion programme or a plant shut-down period. Basically, anticipation inventories store worker- and-machine hours for future needs and limit changes in production rates.

3. **Lot-size inventories:** It is frequently impossible or impractical to manufacture or purchase items at the same rate at which they will be sold. The items, therefore, are obtained in larger quantities than are needed at the moment; the resulting inventory is the lot-size inventory. The set-up time is a major factor in determining the amount of such inventory.

4. **Transportation inventories:** These exist because material must be moved from one place to another. Inventory on a truck being delivered to a warehouse may be in transit for a long time because of the distance to be covered. While the inventory is in transit, it cannot serve a useful function for plants or customers - it exists solely because of transportation time.

5. **Hedge or Speculative inventories:** Firms using large quantities of basic minerals or commodities that are characterized by fluctuating prices can realize significant savings by purchasing large quantities, called hedge inventories, when prices are low. Also, buying extra quantities at an existing lower price will reduce material costs of items scheduled for a price rise later. The saving realized is the true return on the added investment.

At times, there are overlapping functions performed by inventories. Seasonal anticipation inventory will act like safety stock to provide better customer service, for example, as well as reducing the need to react to minor variations in the total demand rate. Thorough consideration of the inter-relationships shared by these inventories is necessary to take advantage of such dual roles that can be played by inventory.
6.1.3. CLASSES OF INVENTORY

Inventory is usually categorized according to their condition during processing. The different classes of inventory are:

1. **Raw materials**: All unprocessed materials - such as mining, agricultural, marine products or other materials used to make the finished products or their components.

2. **Components**: These are parts or sub-assemblies ready to go into the final assembly of the product.

3. **Work-in-process**: These are materials and components being worked on or waiting between operations in the factory.

4. **Finished goods**: They are finished items carried in inventory in a make-to-stock plant or finished goods ready to ship to a customer against an order in a make-to-order plant.

In addition, the term “supplies” is used to identify materials which are consumed by an organization in the performance of its operation. Examples are office supplies, lubricants, etc. These products are designated “MRO” for maintenance, repairs and operations.

6.1.4. COSTS IN INVENTORY

The costs that are affected by each specific decision must be determined when deciding how much inventory to carry. The following classes of costs are involved in inventory decisions:

1. **Ordering costs**:

   The costs of ordering can be either those of placing purchase orders to buy material from a vendor or those associated with ordering a manufactured lot from the plant. When material is purchased, material requisitions and purchase orders must be written, invoices must be processed to pay the vendor and the lots received must be inspected and delivered to stores or process areas. When a manufactured lot is ordered from the plant, costs are incurred for paper work, machine setup, normal start-up scrap that results from the first production of the new setup and other one-time costs that are a function of the number of lots ordered or produced. The sum of all these costs is the ordering cost for the lot.
2. Inventory-carrying costs:

These costs include all expenses incurred by the company because of the volume of inventory carried. The following elements are usually included in inventory-carrying cost: material obsolescence due to changing sales patterns or customer desires, material deterioration because of decay or handling-damage, inventory taxes, insurance, store-room operating cost and capital invested in inventory.

3. Out-of-stock costs:

If material is not available to ship when customers order it, sales may be lost or costs extra and this is the out-of-stock cost incurred. The work of processing a back order (shipping, invoicing and perhaps inventory control paperwork and extra time) can be considerable. The cost of back orders results not only from extra paperwork but also from the time spent by personnel in the various departments who handle the back-order paper, pick and pack the actual shipment and answer customer inquiries.

4. Capacity-associated costs:

The costs that are related to capacity include overtime, subcontracting, hiring, training, layoff and idle-time costs. These costs are incurred when it is necessary to increase or decrease capacity or when too much or too little capacity exists temporarily.

6.1.5. SUMMARY

A firm’s inventory, which is listed as a current asset on a balance sheet, includes all materials stored. This encompasses raw materials, component parts, work-in-process, finished goods, as well as maintenance, repair and operating supplies. The major inventory costs include ordering costs, inventory-carrying costs, out-of-stock costs and capacity-associated costs. These inventories add an operating flexibility in an organization, which would otherwise be lost.
6.1.6. SUGGESTED READINGS


QUESTIONS

1. “Inventories are maintained basically for the operational smoothness.” Justify this statement.
2. How is inventory classified?
3. What are the costs associated with inventories? Discuss them in detail.
4. “Inventory can store labour”. How?
OBJECTIVES:

This lesson on inventory control will help you gain an understanding of the purpose for controlling inventories and also of different methods of inventory control. At the end of the lesson, you will be familiar with the procedures for calculating the Re-order point and the Economic order quantity, and carrying out an ABC analysis.

6.2.1. METHODS OF INVENTORY CONTROL

Inventory control often presents an almost unsolvable dilemma because a sufficient supply of goods is essential to prevent an out-of-stock condition. At the same time, the amount invested in inventory must be justified as measured in costs to the firm. Therefore, control over inventories requires specialized knowledge of the properties of individual items which have significant variations in turnover, use, perishability, handling and inherent physical characteristics.

The first method of inventory control is called Analysis of requirements. In this method, the requirements for a specific order, or short-term requirements are estimated and the items are purchased accordingly. This is also termed as “hand-to-mouth” buying. While it indicates how much to order, it does not reveal when to order.

A second method of inventory control is called Periodic review. A good example of the use of this method is an industrial wholesaler who, on a regular periodic basis, inspects all or parts of his inventory and after estimating expected sales, orders enough merchandise to meet customer demands. Systems of this sort are often refined into perpetual inventory records in order to monitor sales and inventory levels. While in this system the “when” question is answered by using a set, regular time period or date for reviewing inventory, the “how much” is variable and subject to estimation.
The third system, called Constant order quantity, Re-order point system, answers the two basic questions - “how much” by the Constant order quantity, and “when” by the Re-order point. When this method is used with a perpetual record keeping system, the Constant order quantity, Re-order point system proves to be very efficient. Purchases are made when the Re-order point is reached. Then, there is ordered a constant quantity called the Economic order quantity. Its determination, along with that of the Re-order point, are discussed in the subsequent sections.

6.2.2. CALCULATION OF RE-ORDER POINT

There are two factors which enter into the determination of the re-order point, the rate at which a commodity is used and the time it takes to receive the shipment after the order is issued. This time period is called the procurement lead time. As a result of proper materials requirements planning, the detailed demand for every commodity can be known. In all this, a buffer stock is required to cushion against excessive demand during the Re-order lead time. The basic Re-order point is determined by the following formula:

\[
\text{Re-order point} = (\text{Lead time} \times \text{Usage rate}) + \text{Buffer stock}
\]

![Diagram of Calculation of Re-order point](image-url)

Fig. 6.1. Calculation of Re-order point
Refer Figure 6.1. Items can be ordered when a minimum stock level is reached (minimum order level) or at a particular time (periodic review) or triggered by other parts or a combination of all these. Minimum order level techniques give the least inventory and are to be favoured in most circumstances. However, periodic review systems allow parts to be ordered in rotation, a particular advantage when a large number of parts are required from one supplier or when the stock is replenished from a manufacturing unit. In this case, materials inventory control is much simplified and the overall costs are reduced significantly. But balancing is an important concept in materials control and the calculation of re-order point takes this into account.

6.2.3. CALCULATION OF ECONOMIC ORDER QUANTITY (EOQ)

In response to the question of “How many to order?”, the answer for major items is “the minimum, and as frequently as practical”. For the majority of items, however, a general approach is used. The EOQ calculation is a method of identifying the minimum cost of holding stock for each item. It balances the cost of stocks against the cost of re-ordering it. Thus, two costs must be considered in the determination of an economic order quantity, as can be seen from Figure 6.2. Graphing the two costs shows exactly where the total cost curve is at its lowest point. Examine these two cost curves which make up the total cost curve. Holding costs are linear, i.e., the more held in inventory during any period, the greater will be the costs of holding this quantity. Costs of acquisition, on the other hand, are different. Ordering in small quantities means there will be more acquisitions in the course of a year, thus incurring higher costs. Ordering larger quantities will reduce the costs of acquisition in the manner plotted on the graph. At the point where these two cost curves meet, the total cost curve will be at its lowest point. Since it is essential to keep total costs at a minimum, the question of finding the EOQ becomes a matter of finding at which point the costs of holding/carrying are exactly equal to the costs of acquisition or the re-order cost. A mathematical formula can be used to find the EOQ as:

\[
\text{Economic Order Quantity} = \frac{\sqrt{2UC}}{\sqrt{(KP)}}
\]
Fig.6.2. Determination of Economic Order Quantity

where $U$ is the annual usage of the item or commodity, $C$ is the cost of acquisition per order (i.e. the Re-order cost), $P$ is the price per unit item and $K$ is the inventory carrying charges, expressed as a percentage of yearly value. For example, about 200 gearwheels are required each year. The reorder cost is Rs.100 per order and the value of the wheel is Rs.125. We assume a carrying cost of 20% per year. Therefore,

$$\text{Economic order quantity} = \frac{\sqrt{2 \times 100 \times 200}}{\sqrt{125 \times 0.20}} = 40$$

In order to properly use the EOQ equation to determine order size and the resulting frequency of delivery, it is necessary to re-calculate the value of EOQ whenever the variables in the formula change. If, for example, the only change is that usage falls to a consistently lower level, unless a new EOQ is computed, an excessive amount of inventory will accumulate. In like manner, if the price is reduced while other variables remain constant, a higher order quantity will be indicated.

6.2.4. ABC ANALYSIS

ABC analysis is a basic analytical management tool which enables the Management to place the efforts where the results will be greatest. The technique tries to analyse the distribution of any characteristic by money
value of importance in order to determine priority. It underlines a very important principle "Vital few - Trivial many". Statistics reveal that just a handful of items account for bulk of the annual expenditure on materials. These few items, called "A" items, therefore hold the key to business. The other items, known as "B" and "C" items are numerous in number, but their contribution is less significant. ABC analysis tends to segregate all items into 3 categories: A, B and C on the basis of their annual usage. The categorization so made enables one to pay the right amount of attention and minimum effort and expenditure as merited by the item.

The procedure for making ABC analysis is described in the following steps:

1. Calculate rupee annual issues for each item in inventory by multiplying the unit cost by the number of units used in a year.
2. Sort all items by rupee annual issues in descending order.
3. Prepare a list from these ranked items showing item number, unit cost, annual units issued and annual rupee value of units issued.
4. Starting at the top of the list, compute a running total item-by-item issue value and the rupee value of consumption.
5. Compute the cumulative percentage for the item count and cumulative annual issue value.

The normal items in most of the firms show the following pattern:

1. 5% to 10% of the top number items account for 70% of total consumption value. These items are A class.
2. 15% to 20% of the number of items account for 20% of total consumption value. They are B class items.
3. The remaining number of items account for the balance 15% of total consumption value. They are C class items.

A graph on cumulative value against cumulative percent of items is shown in Figure 6.3. to visually see the ABC categories. This approach helps the Materials Manager to exercise selective control and focus his attention only on a few items when he is confronted with so many stores items. By concentrating on "A" category, he is able to control inventories and show "visible" results in a short span of time. By controlling the "A" items and doing a proper inventory analysis, obsolete stocks are automatically pinpointed. But, for ABC analysis to be fully effective, it should be carried out with
standardization and codification. ABC analysis is based on grading the items according to the importance of performance of an item. Some items, though negligible in monetary value, may be vital for running the plant and therefore it may need constant attention. The results of ABC analysis have to be periodically reviewed and updated. It is a common experience that a "C" item, like generator fuel oil in a firm, will become the most high value item during power crisis. However, ABC analysis is a powerful approach in the direction of cost reduction as it helps to control items with a selective approach.

6.2.5. SUMMARY

Controlling an inventory often presents an almost unsolvable dilemma where a sufficient quantity of goods must be available to prevent an out-of-stock condition, but concurrently, the cost of the investment in inventory must be justified. Three methods of inventory control are in common practice, namely "Analysis of requirements", "Periodic review" and "Constant order quantity, Re-order point system". The basic levels of inventory of major importance are maximum quantity to be held in stock, the Re-order point and the minimum quantity to be on hand. Factors which can affect these levels include the time goods are needed, amount needed, demand forecasts,
lead time, price trends, transportation and carrying costs, and quantity
discounts.

6.2.6. SUGGESTED READINGS

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   Techniques", Prentice-Hall of India (P) Ltd., 1986
   New York, 1965
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   Cahners, Massachusetts, 1969
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   Inventory Control", Macmillan, London, 1972

QUESTIONS

1. What is the importance of inventory control?
2. Define the following terms:
   a) Inventory control
   b) Economic order quantity
   c) Lead time
   d) Re-order point
   e) ABC analysis
3. List the factors that must be considered in the establishment of Re-
   order point.
4. Discuss the application and limitations of ABC analysis.
5. How do you calculate the Economic order quantity?
6. What are the benefits which accrue as a direct result of total inventory
   control?
UNIT - VII
Lesson 7.1.

QUALITY CONTROL

OBJECTIVES:

This lesson imparts to you the basic idea of quality control in a production firm. You will become familiar with different approaches to quality control, with more emphasis on Statistical Quality Control.

7.1.1. INTRODUCTION

In operating a business, adequate materials, supplies, equipment and services are essential. These basic elements must not only be available in required amounts, but must also be of suitable quality. Quality is a product's acceptability for an intended use. It can be obtained through clearly stated specifications, reliable vendors who have the necessary ability and capacity, and finally, an inspection and control procedure which matches materials against specifications.

The ultimate goal of quality control is customer or user satisfaction. It encompasses not only Purchasing department adherence to Engineering specifications, but also the vendor's procedure in controlling production. Quality control is responsible for the conformance of items to relevant standards. It has the responsibility to conduct all necessary testing in order to minimize deviation from the specifications set for the many formulations. This protects the firm against financial loss and production loss, apart from keeping the customer satisfied.

7.1.2. APPROACHES TO QUALITY CONTROL

Quality of a product can be assured or controlled by:

1. **Inspection method**: To assure the quality of materials, parts, components, tools, equipments, finished products, processes or methods of production, etc., a 100% inspection or a sample inspection is done. There are three basic areas of inspection, namely receiving
inspection, in-process inspection and final inspection. In the receiving inspection, inspections are performed on all incoming materials and purchased parts. In the in-process inspection, the products are inspected as they are in process. In the final inspection, all finished products are finally inspected prior to sending them to the customer. The philosophy of inspection is only “preventive” and not “remedial”. In short, inspection is the method of measuring and/or checking the quality of a product in terms of specific standard. Lesson 7.2. deals with inspection on a broader scope.

2. **Statistical quality control**: Any attempt to inspect quality in the finished product by usual inspection methods and devices is time-consuming and costly. Besides, in a continuous production process, 100% inspection may not be found practicable. Certain statistical techniques have been devised to evaluate machines, materials and processes by observing capabilities and trends in variation so that continual analysis and predictions may be made to control the desired quality level. These statistical techniques are called statistical quality control methods. The next section will explain this in detail.

3. **Automated control**: Technological advancement has made it possible today to control the quality automatically. Quality control devices are being built into the machines, which control the quality of products during the process automatically. Computers are also used. They may be “on-line” or “on-line real-time” computers. They are located at several key operations, while being tied to the central controlling computer. The output of the machine or the process is constantly monitored and defects are reported in “real-time” or quickly. The computer keeps track of defects turned out of the process or machine. If the proportion of defectives goes up, the computer reports to the person responsible for locating the trouble or for taking necessary actions. Sometimes, the computer adjusts the process or sets the machine right automatically.

**7.1.3. STATISTICAL QUALITY CONTROL**

Statistical Quality Control can be described as an application of statistical methods of sampling and tests of significance to ensure that the process of production is under control and to give a “stop” signal when it goes out of control. Any manufacturing process, however good, suffers from variation of quality in its production. Chance plays its role in production also. Statistical
Quality Control methods ensure that the variations observed are due to only the chance factor. As soon as other identifiable or assignable causes of variation enter into the process, these methods can immediately detect them. The variations caused by assignable causes such as negligence of operation, fault of a machine, etc. once detected by Statistical Quality Control methods can be removed. These methods can be useful to:

a) Control the quality of finished products and the quality of products during the manufacturing process,

b) Decide whether to accept or reject a lot of products already manufactured and also the incoming materials, parts, components, etc. and

c) Provide management with quality information of the products manufactured in its own factory.

7.1.4. TYPES OF CONTROL CHARTS

Process control charts are commonly used in Quality control to maintain a continuous evaluation of the manufacturing process. A control chart is simply a frequency distribution of the observed values plotted as points in order of occurrence so that each value has its own identity relative to the time of observation. Points on the control charts may or may not be connected. The chart is provided with limit lines, called control limits, having, in general, one upper control limit (UCL) and one lower control limit (LCL).

A process is said to be in control, if the observed values are influenced only by chance causes and fall within the limits, out of control when assignable causes seem to be operating in the system and the observed values fall outside the limits. The interpretation of the control charts is important because wrong interpretations lead to wrong actions, which worsens the situation instead of improving the process. It should be remembered that the control limits of the process control charts do not represent the performance limit or limits of the manufacturing process nor do they represent the specification limits of the manufacturing drawing. The various types of control charts have been developed by the statisticians to improve product quality and to reduce costs of manufacture.
Control charts can be divided into two types:

(1) **Control charts for variables**: The characteristic which can be measured is called as variate. For these variates, we may be interested in controlling their mean \((X')\) or the range of variation \((R)\), or the standard deviation \((\sigma)\). Control charts prepared to control \(X'\) and \(R\) come under this category. Samples are drawn at regular intervals and measurements are taken. The size of the sample is such that within the sample, the variation is due to chance alone, the variation, if large, from one sample to another it is due to other causes. The charts are a plot of difference between the highest and lowest values in each sample against time. In general, where control charts for variables, either \(X'\) or \(R\), are undertaken, some or all of the following purposes are present:

To secure information to be used in establishing or changing specifications or in determining whether a given process can meet specification.

To secure information to be used in establishing or changing production procedure by either elimination of assignable causes of variation or fundamental changes in the procedure.

To secure information to be used in establishing or changing inspection procedures or acceptance procedures, or both.

To provide a basis for decisions during the process as to when to hunt for causes of variation and take necessary corrective action.

To provide a basis for decisions on acceptance or rejection of manufactured or purchased product.

Figure 7.1. shows an example of these two charts.

(2) **Control charts for attributes**: The characteristics which cannot be measured are called attributes. For example, defects such as a crack in a part or bubbles in a glassware cannot be measured. We can note only that there is any defect or not. If any defect is seen, the product is to be rejected otherwise accepted. Such control charts for attributes denoted as p-charts and np-charts. The fraction defective \((p)\) may be defined as the ratio of the number of defective articles found in any inspection or series of inspections to the number of articles actually inspected. Fraction defective is nearly always expressed as a decimal fraction. The percent defective \((np)\) is 100\(p\), i.e. 100 times the fraction defective. For actual calculation of control limits, it is necessary to
Fig. 7.1. A Typical $X'$ and $R$ control chart for variables

use the fraction defective. For charting, and for general presentation, the fraction defective is generally converted to percent defective. As applied to 100% inspection a control chart for fraction defective may have any or all of the following purposes:

- To discover the average proportion of defective articles or parts submitted for inspection over a period of time.
- To bring to the attention of management any changes in the average quality level.
- To discover those out-of-control high spots that call for action to identify and correct causes of bad quality.
- To discover those out-of-control low spots that indicate either relaxed inspection standard or erratic causes of quality improvement.
- To afford a basis for judgement whether successive lots may be considered as representative of a process.
Figure 7.2 Shows an example of a typical p control chart for attributes

(3) Control charts for defects: This is denoted as c-chart. The p or np chart applies to the number of defectives in subgroups of constant size, whereas c-chart applies to the number of defects in subgroups of constant size. A defective is an article whereas articles lack of conformity to specification is a defect. Every defective may contain one or more defects. In certain industrial products, it is the number of defects in an article or in a unit that makes the article useless. If the number of such defects are within the specification specified by engineers, the product is accepted, otherwise it is rejected. For constructing the control chart of number of defects, the ratio of number of defects in all samples to the total number of items inspected in all samples is calculated.

7.1.5. SUMMARY

In quality control, the word “control” implies regulation, and regulation implies observation and manipulation. It suggests when to inspect, how often to inspect and how much to inspect. Quality of a product can be assured or controlled by inspection, statistical quality control and automated control. Certain statistical techniques have been devised to evaluate machines, materials and processes by observing capabilities and trends in variation so that continual
analysis and predictions may be made to control the desired quality level. These statistical techniques help in statistical quality control. Process control charts are commonly used in quality control to maintain a continuous evaluation of the manufacturing process. There are different types of control charts like, control charts for variables, control charts for attributes and control charts for defects.

7.1.6. SUGGESTED READINGS


QUESTIONS

1. Define the terms Quality, Control and Quality Control.

2. What are the different approaches to Quality control?

3. Differentiate between inspection and Quality control.

4. Fully describe the following terms giving examples of
   a) an attribute
   b) a variable

5. What is a process control chart? Discuss the different types of control charts.
Lesson 7.2.

INSPECTION

OBJECTIVES:

This lesson attempts to explain to you the need and nature of the inspection function in a manufacturing firm. You will also be presented with the different ways in which this function can be carried out.

7.2.1, INTRODUCTION

In operating a business, adequate materials, supplies, equipment and services are essential. These basic elements must not only be available in required amounts, but must also be of suitable quality. In industrial purchasing, quality is a product’s acceptability for an intended use. To assure this quality of materials, parts, components, tools, equipments, finished products, processes or methods of production, etc. inspection and testing is done by competent personnel called inspectors. The responsibility of inspection and testing rests with the inspection department. This department sees whether:

a) the purchase department has procured materials, parts, components, tools, equipments, etc. as per the specifications or standards.

b) the production department has produced standard quality products and standard processes, methods of production and tools and equipments are used in that department.

c) the repair and maintenance department has worked properly to repair and maintain the tools and equipments used in the factory, and

d) the stores department has taken proper care in storing materials until they are used and finished products until they are sold.

On the basis of information given and suggestions made by this department, after the inspection and/or testing is over, the concerned department takes corrective steps to improve the defects.

7.2.2, INSPECTION PROCEDURE

Inspection checks for quality. Some items are verified individually because of their nature, value or size, although in other cases, representative sampling
is acceptable. Some firms inspect at the vendor's plant to avoid handling and shipping costs in the event of rejection. It also prevents production delays or loss of production time in the buyer's plant. Within the plant, the principal phases of inspection are receiving inspection, tool and gauge inspection, process inspection and product inspection.

Inspection varies with the degree of quality required. For example, some products need little inspection of work in process. In other cases, it might be necessary to inspect each part produced on a particular operation, using precision quality control instruments. Such instruments facilitate more accurate inspection with fewer inspectors. Attribute inspection determines whether a particular quality characteristic is present in the product, within acceptable limits of variation from the quality standard.

Along the flow of materials through the manufacturing process, many inspection points can be identified. The principal points are receiving for incoming materials, assemblies of goods in process and final goods prior to storage and shipments.

7.2.3. DIFFERENT KINDS OF INSPECTION

Based on the location of inspection, it can be classified as centralized and decentralized inspection. It depends on various factors like the type of material to be inspected, process flows, types of inspection and testing machines and equipments, etc.

When the testing and inspection machines are to be kept in special rooms with various facilities and they cannot be taken to the job place, and materials, products, parts, components, etc. which are to be inspected are taken from the normal flow to the inspection department, it is called Centralized inspection. It saves the time of inspectors because they need not move out to various departments for their work, instead they receive in the inspection department, what they have to inspect. But central inspection cannot be used to inspect very heavy items, items in huge quantities and such products which pass continuously from one process to another and maintenance of that continuous flow is a must. Moreover, central inspection may lengthen the production cycle when the inspectors are busy and few departments may have to wait for a long time. It also increases the cost of material handling and transportation.
Inspection at the job place, also known as Decentralized inspection is used to resolve the problems mentioned above. Here the inspectors move from one place to another place, or from one machine to another machine, or from one process to another process etc. to inspect materials, parts, components, tools, equipments and products during the various stages of production and the finished goods. This type of inspection saves time, money and labour. Materials are not required to be handled and transported very often to and from central inspection point. The duration of production cycle becomes short to some extent. But the departments who want to get their materials, parts, products, etc. inspected, have to wait till the inspectors come. Workers will have to wait for they can start their work or machines only after inspection. Moreover, inspectors have to move to different places for inspection work with their inspection tools. If their testing equipments are delicate, it is not advisable to carry them everywhere. In such circumstances, only central inspection is advisable.

7.2.4. SUMMARY

Suitability for intended purpose and total cost are the Purchasing department’s basic criteria in buying a material, product or process. The goal of inspection is to assure conformity of materials or products to standards essential for customer or user satisfaction. Thus Inspection is one method of maintaining effective quality control. It may be carried out at the job place or in a separate inspection department.

7.2.5. SUGGESTED READINGS


QUESTIONS

1. What are considered to be the principal places of inspection? Why?
2. Compare and contrast between centralized and decentralized inspection.
3. Describe the inspection procedure in a manufacturing firm.
4. Discuss the activities of an inspection department.
UNIT - VIII

Lesson 8.1.

COMPUTERS AND MATERIALS MANAGEMENT

OBJECTIVES:

This lesson will present to you, a brief second look at the Materials Management function, but as a computerized function. You will be able to specify the role of computers in Materials Management and justify them with the advantages that a computerized system offers.

8.1.1. ROLE OF COMPUTERS IN MATERIALS MANAGEMENT

In Materials management, the transaction-processing consisted of materials accounting based on receipts, issues, returns and rejections. The computers play a significant role in materials decision-making related to these transactions. For the purpose of materials decision-making, comprehensive data-bases can have three components of purchasing, inventory and materials review, which are inter-related and integral to the Material Management function.

The purchasing database can help creating a Corporate Management Information System (MIS) for monitoring of purchase indents upto acceptance of tenders, monitoring of purchase orders against schedules of delivery, analysis of lead-time delays, vendor-rating and monitoring payments against deliveries. The inventory database can help in creating a Corporate MIS for preparation of standard specifications for regular consumption items, prompt inspection and acceptance of delivered goods, preparation of receipt documents, monitoring of stock balance, purchase dues and indent dues; monitoring of procurement of regular consumption items, decentralized control of consumption, analysis of consumption and movement of items for control, forecasting and budgetary control of consumption and procurement and so on. Materials review database can help in creating a Corporate MIS for the on-going review of the various control parameters such as re-order level,
re-order quantity, the phasing of deliveries for "A" class items, the bulk purchasing of "B" and "C" class items and so on. Basically, materials review should look critically at all the expected norms of purchasing and inventory so that a dynamic adjustment is possible before the on-set of any crisis.

8.1.2. REQUIREMENTS FOR COMPUTERIZING

The critical element in the successful use of computers in Materials Management is the development or building of an adequate database. Within such a database, three major files which include the kinds of information described below, need to exist.

1. **Item Master File**: In this file, every item master record fully identifies the item that is to be ordered. This record is usually a part of a computer bill-of-material file. It contains all the unique item data needed by purchasing, like the Stock number description, lead time, Costs, inventory, commodity codes, ordering policy, qualified suppliers, historical data and forecast.

2. **Vendor Master File**: The vendor file contains this information about each vendor - name, address, contract, terms and conditions, shipping data, performance data, major commodity codes, purchasing history and all open purchase order numbers.

3. **Open Order File**: The open order file is the key to any purchasing system. In conjunction with the other files, it provides information necessary to initiate and evaluate purchasing activity. The file is created when the order is written and is maintained until the order is received, invoiced and paid. It contains all updated order information such as quantity, prices, shipping data, receiving data, receiving inspection data, invoice and invoice payment data.

Once such a database is built, it can then be integrated and made operational, where computations, query-handling and report generations can take place, using suitably coded computer software.

8.1.3. ADVANTAGES OF COMPUTERIZED MATERIALS MANAGEMENT

Computers make records and reports available from a single information base. The computerized materials management system offers following advantages:
1. Economy of time results from computerized preparation of all necessary records and analytical reports. Peak loads and end-of-month overtime are reduced or eliminated.

2. Accurate records make all the necessary facts available when needed.

3. Direct access and control of all elements of Materials Management is the direct result of a well-designed computerization.

4. Due to the greater efficiency of data processing, every transaction appears in a legible, easily audited, permanent record, and analyses of budgets and costs are possible to a greater degree than ever before.

5. Company prestige is enhanced by prompt and accurate payment of all obligations. Neatly printed, accurately documented reports make a favourable impression in all communications.

6. Management decisions are founded on all the facts available. Computerization makes information available in greater detail and in less time than ever before.

7. Computerization permits the use of Statistical methods and Operations research projects at an economical level.

To the advantages listed above, firms with computerized purchasing systems reap the following benefits:

1. Standardizing information and technology minimizes misunderstandings and misinterpretations, thus improving communication.

2. Identical data is available concurrently to all authorized personnel involved in a specific decision or action. Duplication is eliminated.

3. Savings are effected in the amount of floor space which otherwise would be used for the files.

4. Lower inventory investment and costs are achieved through more accurate data and faster procedures.

8.1.4. SUMMARY

A computerized system is a valuable tool which is characterized by high-speed manipulation and computation of data. Extending their application to Materials management, they greatly assist and improve the quality of decision-making in purchasing, inventory and materials review. Basically, a computerized materials management system is a database with an item
master file, a vendor master file and an open order file. Such an organized representation of data, coupled with the computation speed and accuracy, provides many advantages over manual Materials Management.

8.1.5. SUGGESTED READINGS


QUESTIONS

1. Discuss the role of computers in Materials Decision-making.
2. Explain the benefits in using a computerized Materials Management system.
OBJECTIVES:

This lesson aids you to review the inventory function and its characteristics in a manufacturing firm and to identify the need and purpose for Computerized inventory management systems. It will also help you in the conceptual design of such a system.

8.2.1. USE OF COMPUTERS IN INVENTORY MANAGEMENT

At the inventory management stage, computers are used to control the level of inventories and to provide materials at the right time. Computers can handle various data such as price, lead time, cost of ordering, cost of carrying, historical data on delivery performance and so on very easily. Various techniques such as ABC analysis, EOQ calculation, etc. (discussed in Lesson 6.2.) can be easily programmed into the computer so that tedious and time-consuming calculations are avoided. Also movement analysis, lead-time analysis, vendor rating, etc. can be computerized and this permits the management to carefully evaluate and take scientific decisions so as to control the inventory levels. Factors such as reserve stock, safety stock and re-order points require statistical and mathematical analysis, which the computer software can compute and analyze. Computers can also print out the stock status, orders pending execution, expected consumption etc. so that follow-up can be done on a selective basis to keep inventories at minimum.

8.2.2. COMPUTERIZED INVENTORY MANAGEMENT SYSTEM

Inventory systems generally require the use of several data files. One file, referred to as the Master file, keeps track of the quantity of each item presently in stock. In addition, it may also keep track of the location of each item in the warehouse, the cost of the item, the re-order point, the quantity currently on order, and the name and address of the vendor the item is purchased from. This allows the user of the system to locate an item quickly, get a listing of goods that need to be ordered, create and print new orders automatically and perform other similar stock-control tasks.
**Fig. 8.1. Database files for an Inventory Management System**

To keep track of each individual transaction that occurs within the business, separate data files called Transaction files are maintained. One such file might keep track of individual sales transactions as to whom items were sold, when, for how much and the invoice or receipt number. A second transaction file might maintain an on-going record of all new stock received. Figure 8.1. shows the relationship between the Master file and two such Transaction files. The Transaction files maintain a history of all individual transactions involving the sale and receipt of goods, while the Master file maintains the current status of goods in stock at any given moment by using information supplied directly from the two Transaction files. In a sense, the Master file is an up-to-date summary of all activities in the two Transaction files.
Fig. 8.2. Inventory Management menu sub-systems

A key-field that is unique for every record and existing in the Master file and in the Transaction files in identical terms, will be used as an identifying code. This code is usually a part number. Without the use of key-fields, data can be very difficult to manage. The primary output from the Inventory system Master file will be reports concerning the status of the inventory and purchase orders for re-stocking. The inventory system can be simplified and its functions can be represented by four menu shown in Figure 8.2. Menu-I shall be overall inventory system menu. Depending on user's choice it would activate the corresponding programme which would result in display of secondary level of menu - II or III or IV. The main menu would give the user access to inventory, sales or stock master files. Use of secondary level menu shall provide user option to record new parts, print reports or amend the existing records. Suitable software can be developed to implement this Inventory system design.

8.2.3. SUMMARY

The main purpose of inventory control is the monitoring of the stock levels and this is achieved by recording stock movements on stock records. Use of computers for this purpose, offers efficiency and accuracy in inventory control, not to mention the time saved and the ease enjoyed. Such an inventory
system will provide the user with reports of all goods in stock, items that need to be re-ordered, and items on order, and will automatically generate purchase orders. The general design of inventory system includes certain designated data files, wherein each item in the store has a unique key field. Relevant software can be coded to integrate them and to implement this inventory management system.

3.2.4. SUGGESTED READINGS


QUESTIONS

1. Discuss the applications of a computerized inventory management system.
2. Outline the general design of an Inventory system.