**MBA 801**

**Chapter 1 - Production and Operations Management**

Operations management deals with the production of goods and services people buy and use every day.

it enables organizations achieve their goals thru efficient acquisition and utilization of resources

Every organization has an operations function

Production and Operations management converts inputs into the organization's goods and services.

Any Organization is divided into basically 3 functions;

- Finance

- Production and Operations

- Marketing

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These functions overlap. The interdependency of the major functions is depicted by overlapping circles.

These 3 functions and other supporting functions perform different but related activities necessary for the operation of the organization.

The functions must interact to achieve the goals and objectives of the organization.

**Operations**

The Operations function consist of all activities related to producing goods and services.

it is the core of most organizations.

To ensure desired outputs are obtained, measurements are taken at various points of the transformation process(feedback) and compared with established standards to determine whether corrective action is needed(control).

The essence of the operations function is to add value during the transformation process.

The value added is the difference between selling price and cost price. The greater the value added, the greater the effectiveness of the operations.

In NGOs, the value added is value to the society. while in business organizations, the greater the profit.

Profits can be invested in R&D, New Investments etc.

Organizations can eliminate operations that do not add value and also reduce the cost of input.

**Finance**

The finance function is made up of activities related to securing resources at favourable prices and allocating those resources throughout the organization.

Generally, the finance and operations management personnel cooperate by exchanging information and expertise in such activities as budgeting, economic analysis of investment proposals and provision of funds.

Evaluation of alternative investment in plant and equipment requires inputs from both operations and finance people.

The amount and timing of funding is very important.

**Marketing**

Marketing is concerned with sensing, serving, and satisfying the needs and wants of the present and potential customers of the organization.

Advertising and pricing decisions are made by the marketing people.

Operations department needs information about demand over the short to intermediate term so that it can plan accordingly (e.g purchasers raw materials or schedule work). In addition, the design department also needs information that relates to improving current products and services

and designing new ones.

Other core functions are Accounting, Public Relations, Personnel, purchasing etc.

**Manufacturing and Service Operations**

Manufacturing implies production of a tangible output while services implies an act.

**Differences Between Manufacturing and Services**

|  |  |  |
| --- | --- | --- |
| **S/N** | **Manufacturing** | **Services** |
| 1. | Physical and tangible | Intangible and Perishable |
| 2. | Output can be inventoried | Output cannot be inventoried |
| 3. | Low customer contact | High customer contact |
| 4. | Long response time | Short response time |
| 5. | Large facilities | Small facilities |
| 6. | Capital Intensive | Labour Intensive |
| 7. | Quality easily measured | Quality not easily measured |
| 8. | Serves local, national, regional or international markets | Serves only local market |

**Similarities between manufacturing and service operations**

1) Both have processes that must be designed and manage effectively.

2) Some kind of technology can be used.

3) Both are concerned about quality, productivity and timely response

4) They make choices about capacity, location and layout of facilities.

5) They both deal with retailers.

**Industrial Revolution**

Cottage Systems - 1770s

Substitution of Machine power for Human power(James Watt) - 1764

Division of labour(Adam Smith) - 1776

Interchangeable parts (Eli Whitney) - 1790

**Scientific Management**

The scientific-management era brought widespread changes to the management

of factories.

1. Skill, strength and learning ability were determined for each worker so that individuals could be placed in jobs for which they were best suited.

2. Stopwatch studies were used to precisely set standard of output per worker on each task. The expected output on each job was used for planning and scheduling work and for comparing different methods of performing tasks.

3. Instruction cards, routing sequences, and materials specifications were used to coordinate and organize the shop so that work methods and work flow could be standardized and labour output standard could be met.

4. Supervision was improved through careful selection and training. Taylor frequently pointed out that management was indeed negligent in the performance of its functions. He strongly believed that management had to accept planning, organizing, controlling, and methods determination responsibilities, rather than leave these important functions to the workers.

5. Incentive pay systems were initiated to increase efficiency and to relieve foremen of their traditional responsibility or driving workers.

**Human relations and Behaviourism**

During the industrial Revolution, factory workers were largely uneducated, unskilled, and undisciplined, having come fresh from farms. These workers generally had a basic dislike for factory work. They were however forced by circumstances to take to the jobs, since there was nothing for them to live on. Factory managers often had to develop stringent controls to force them to work hard. This practice of stringent controls continued into the 1800s and early 1900s. Basic to this management method was the assumption that workers have to be placed in jobs designed to ensure that they would work hard and efficiently.

However, between World War 1 and World War II, there began to emerge in the United States a philosophy among managers that workers were human beings and should be treated with dignity while on the job.

The studies produced confusing results about the relationship between physical environment and worker efficiency. The researchers were to later realize that human factor must be affecting production.

This was about the first time that researchers and managers alike recognized that psychological and sociological factors affected not only human motivation and attitude, but production as well.

In this regard therefore, operations managers need to create an organizational climate that encourages employees to devote their energy, ingenuity, and skill to the achievement of organizational objectives.

**Chapter 2 - Operations Strategy**

Operations strategy is a vision for the operations function that sets an overall direction or thrust for decision making.

This vision should be integrated with the business strategy and is often, but not always, reflected in a formed plan.

The operations strategy showed result in a consistent pattern of decision making in operations and a competitive advantage for the company

**Relationship Between Operations Strategy and Corporate Strategy**

- Begins with market analysis

- Formulation of corporate strategy

- Develop the capabilities and strength to meet customer's demand

**Corporate strategy**

In any business organization, it is the responsibility of top management to plan the organization's long-term future.

In this regard therefore, corporate strategy defines the businesses that the company will pursue, new threats and opportunities in the environment, and the growth objectives that it should achieve.

Also addressed, is business strategy i.e. how a firm can differentiate itself from the competition. The various alternatives could include producing standardized products instead of customized products or competing on the basis of cost advantage versus responsive delivery. Thus, corporate strategy provides an overall direction that serves as the framework for carrying out all the organization's functions. In the sections that follow, we shall discuss the basic alternatives involved in corporate strategy and how global markets affect strategic planning.

**Strategic Alternatives**

(i) Determining the firm’s mission

(ii) Monitoring and adjusting to changes in the environment

(iii) Identifying and developing the firm’s core competencies

**Strategy and Tactics**

A mission statement provides a general direction for an organization and gives rise to organizational goals.

Strategies are plans for achieving goals.

Tactics are the methods and actions used to accomplish strategies.



Corporate strategy's scope is the entire organization while the operation strategy's scope is the operation aspect of the organization.

It has a narrow scope and it is an important link to the corporate strategy.

The formulation of corporate strategy must consider the realities of operations strength and weaknesses.

It must also be consistent with corporate strategy.

**Elements of operations strategy**

1) Positioning the production system

2) Focus on production

3) Product /service plans

4) Production processes & technology plans

5) Allocation of resources

6) Facility plans

7) Market analysis [Market segmentation and Needs analysis]

**Chapter 3- Forecasting**

Forecasting is futuristic and helps manage uncertainties.

Well managed businesses plan to mange demand by;

1) Planning for demand

2) Recognizing and accounting for all sources of demand

3) Pre-processing of demand

Forecasting is an integral part of business planning.

**Importance of forecasting in production and operations management**

1) New facility planning

2) Production planning

3) Work force scheduling

**Observation of demand measurement**

Master planning team composed of Finance, Marketing and Operations should be responsible for taking care of coordinating demand management activities.

- Account for all sources of demand

- Influence demand

- Evaluate impact of any demand management plan on capacity and cash flow

**Time Horizon in Forecasting**

1) Short range (up to 3 months)

2) Medium range(From 3 months to 1 -year)

3) Long range (1-5 years)

**Importance of sales forecast**

Estimation of demand is one of the important piece of data used by management and takes a central stage in planning efforts.

**Sales forecasting method**

There are divided in two types;

- Quantitative Method :This involves the application of statistical techniques of varying

degrees of sophistication

- Qualitative Method: It relies primarily on judgment to produce sales forecasts.

**Qualitative Methods**

1) Users 's Expectation

2) Sales force Composite

3) Jury of Executive Opinion

4) Delphi Technique

**Quantitative Methods**

1) Market test

2) Time series [Exponential Smoothing and moving average]

a = smoothing constant

= Current sales

 = Smoothed sales

3) Statistical demand analysis

**Chapter 4 - Process Management**

Process involves use of organization's resource to provide value.

Processes underline all work activity and are found in all organizations, as well as all functions of an organization.

Processes are nested within other processes along an organization's supply chain.

Process management is the selection of the inputs, operations, work flows, and methods that transforms input into outputs.

**Major types of process decisions**

1) Process choice: The choice depends on volume and degree of customization.

*i) Project process* - High degree of customization, Large, Complex, Makes use of Skills and resources at particular stages and then have little use for them till the end of the time.

*ii)Job Process:* Flexibility needed to produce a variety of goods and services in significant quantities. Volume is low, customization relatively high.

*iii)Batch process:* Differs in respect of volume, variety and quantity. Volume is high for same or similar products and services repeatedly.

*iv) Line process:* Volume is high, Product/Services standardized. Materials move linearly from one operation to the next in a fixed order. Line process is called mass production. It fits in a line flow.

*v) Continuous process:* Extremely high volume and standardized production with rigid line flows. It is capital intensive and used in manufacturing

2) Degree of Vertical Integration

How much of the production of goods and services a company can bring under its own roof. If a company cannot perform some processes, it relies on out-sourcing

3)Resource flexibility

4) Customer involvement

5) Degree of automation: This help reduce labour cost.

**Designing Processes**

1) Process Re-engineering: Select a critical process, provide strong leadership, provide cross functional teams, Integrate Information Technology, Clean slate Philosophy (Customer driven orientation) and Process analysis

2) Process Improvement: Systematic study of the activities and flows of each process to improve it. It makes use of process charts and flow diagrams.

**Chapter 5 - Job Design**

Job design entails matching tasks or work activities to individuals or task groups.

This is usually done by specifying a job's content, the employee skills and training needed to perform that job, and the degree of specialization appropriate for the job.

The aim is to increase the efficiency of the organization and with the goal of enhancing working conditions.

In addition, job design improves productivity through consideration of technical and human factors. It also increases the quality of the final product or service.

Job designers are concerned with who will do a job, how the job will be done, and where the job will be done.

The job design must be:

i. Carried out by experienced personnel who have the necessary training

 and background

ii. Consistent with the goals of the organization

iii. In written form

iv. Understood and agreed to by both management and employees.

There is need to realize that there are factors that affect job design.

**Approaches to Job design**

- Efficiency approach

- Behavioral approach

**Job Specialization**

It involves a narrow range of tasks and a high degree of repetition for greater efficiency and quality specialization results in the following benefits;

- less training time needed per employee because the methods and procedures are limited

- faster work pace, leading to more output in less time

- lower wages paid because education and skill requirements are lower

Narrower defined jobs lead to;

- poor employee morale, high turnover, and lower quality because of the monotony and boredom of repetitive work;

- the need for more management attention because the total activity is broken into a larger number of jobs for a large number of employees, all of whom have to be coordinated to produce the entire product or service

- less flexibility to handle changes or employee absences

**Alternatives to Job specialization**

It is clear people work for individual needs, social needs and economic needs. There are alternatives for specialized jobs to provide for a broader range of needs satisfaction.

They include;

1) Job rotation

2) Job Enlargement

3) Job Enrichment

4) Team production

5) Empowerment

**Chapter 6 - Management of Technology**

Technology may be defined as the know-how, physical things, and procedures used in the production of products and services.

The “know-how” component of this definition is the knowledge and judgement of how, when, and why to employ equipment and procedures. Craftmanship and experience are naturally embodied in this knowledge, but unfortunately, cannot be written into manuals or routines.

The second component, physical things, are the equipment and tools.

The last component, procedures, is the rules and techniques for operating the equipment and performing the work.

You need to understand that technologies don’t occur in a vacuum, rather, they are embedded in support networks.

A support network comprises the physical, informational, and organizational relationships that make a technology complete and allow it to function as intended.

**Primary Aspects of Technology**

1) Product technology [firm’s engineering and research groups develop when creating new products and services]

2) Process technology [Firm's employees use to do their work]

3) Information Technology[firm’s employees use to acquire, process, and communicate information]

*Product Technology:* Developed primarily by engineers and researchers to translate into new products and services for the firm's customers.

- It can also extend conventional capabilities.

- There is need to seek co-operation with marketing personnel.

- Operations department will determine how the goods and services can be produced effectively.

- Requires design systems to support field installation and maintenance.

*Process Technology:* The methods by which an organization does things usually rely on the application of technology.

Not all functional areas in the organization use technology.

*Information technology:* It is increasingly being used to acquire, process and transmit information to make effective decisions e.g. telecommunications, office technologies etc.

**Management of Technology**

It links R & D, Engineering, IT & Management to plan, develop and implement new technological capabilities that can accomplish corporate and operational strategies.

Managers need to be knowledgeable about technology used in their operations. They also need to understand the technology and it's benefits.

**Role of technology in business Performance**

- Technology is very important as it plays a pivotal role in creating new products and improving processes

- Investments in technology increases the firm's profit

- To be worthwhile, technology must be appropriately applied to the operations of the business

**Information Technology**

Information Technology(IT) is very crucial and is in all functional areas of any organization.

It is a known fact that computers are spawning new innovations either directly or not.

Information Technology makes functional coordination easier and links a firms basic processes.

Information Technology comprises of computing and telecommunications technologies.

Information Technology can be partitioned into 4 groups;

1) Hardware

2) Software

3) Databases

4) Telecommunications

*Hardware:* This is made up of computers and devices connected to it. Higher speed, memory and processing capability have greatly taken technological changes.

*Software:* These are computer programs that make the hardware work and to carry out different application tasks.

Computer users use application software to solve several problems. It allows information to be captured, stored, processed and implemented.

There are software to aid various manufacturing capabilities as well as executive support systems(EIS).EIS allows managers to quickly and effectively evaluate business issues.

*Databases:* A database is a collection of inter-related data on a storage media. It has several application areas e.g. marketing, criminology etc.

*Telecommunications:* It ensures communication between several computes. The main purpose is the transmission of signals[data & voice] between remote locations.

There are many types of networks. The ability of computers to communicate to one another in a far location gave rise to the Internet.

**Creating and applying technology**

This is a major challenge. There is need to examine the concept of innovation process which is aimed at creating and applying technology to improve firm's products, production process and services.

The innovation process are divided into 3 stages;

Stage 1 - Basic Research

Stage 2 - Applied Research

Stage 3 - Development

*Basic Research*

A study that explores the potential of narrowly defined technological possibilities, and attempting to generate new knowledge and pioneer technological advances.

- It seeks fundamental truths,

- Success comes from inventive(creative) minds

- May be capital intensive

*Applied Research*

It attempts to solve practical problems involved in turning idea into a commercial feasible product, process or service.

- It is carried out by large firms

- It is more directed than basic research

*Development*

It refers to activities that turn technology into detailed designs and processes.

- Products and processes are developed with an eye marketability and ease of production.

- Both large and small firms are involved in development.

- It begins with the recognition of production needs and goes thru several phases;

1) Concept development

 - Product idea is conceived

2) Technical feasibility

 - Test is conducted whether the concept will work or not

3) Detailed product / service design

 - Prototypes of the products maybe built, tested and analyzed

4) Process design

Detailed design goes beyond engineering, with operations and marketing personnel getting involved in assessing the design for its manufacturability and marketability.

Details of product characteristics are examined by utilizing lists of specifications, process formulas, and drawings. Marketing department uses trial tests in limited markets or with consumer panels to help measure market reactions to specific product features or packaging. At times, test results may lead to changes in the product or the way it is presented before it is actually produced and marketed. Tests such as these often provide reasonable assurance that the product is technically feasible, can be produced in quantity at the desired quality level, and has customer appeal.

At the final development phase, process design, final decisions are made regarding the inputs, operations, work flows, and methods to be used to make the product.

Development stage is very crucial to a firm’s future profitability. A future-looking organization that is technology and resource - rich should always develop and compete with the new technologies that they helped create. That is, they should continue to develop innovations into

products and services. This is the only way to prevent organizational complacency from depriving them of the initial leadership.

**Choosing Technology**

Managers need to make intelligent and informed decisions about new technology because of the rapid rate of change coupled with the availability of numerous technologies as it will affect the human and technical aspect of operation.

**Assessing the technologies**

New technologies should create competitive advantage either by adding more value to the customer or reducing cost of production. Factors to consider are;

1) Cost reduction

2) Quality, time and flexibility

3) When to launch new technology

4) Economic justification

**Implementation guidelines for new technologies**

1) *Technology acquisition*

- New technology gotten from Internal, Inter-firm relationships and purchasing from suppliers

- There are 4 approaches towards establishing Inter-firm relationships;

i) Outsourcing research

ii) Obtaining a license

iii) Enter a joint venture(JV) or alliance

iv) Buying out

2) *Technology Integration*

There is need to raise cross-functional teams to implement new technologies and bridge gap between R&D and manufacturing. It brings several specialist e.g. IT, engineers, buyers etc together and is called concurrent engineering.

It allows the firm to significantly shorten time to market and meet time-based and quality competition better. These teams are after charged to take a broad, systematic outlook in choosing technologies to pursue.

3) *Technology and Human resources*

It looks at how technology affects human resources.

Operations managers must anticipate this and prepare employees.

Education and employee involvement help a firm identify new technological possibilities and then prepare employees for the jobs modified or created when the new technologies are implemented.

4) *Leadership*

Managing technology requires managers to play several conflicting roles.

Managers should have a good technical vision and vigorously pursue it.

Managers also play the role of advocates by making strong commitment to the project.

They can also act as gatekeepers by keeping everyone focused.

There is need to raise a cross functional project team to lead and co-ordinate the project. the project manager should promote the project at every given opportunity.

**Chapter 7 - Site Selection**

Site selection is deciding on a location for constructing, expanding or acquiring a physical entity of a firm in order to reach new markets, increase production capacity of serve customers better

It could be for either a manufacturing or a service organization.

It can also be for domestic or an international company.

The ease of the decision making process varies from small to large firms.

**Factors in site selection**

1. Staffing

 - Availability of personnel

 - Labour cost

 - Social laws

 - Labour productivity

 - Strong trade union power

 - Education level of available workforce

2. Inherent local condition

 - Good weather

 - Culture

 - Ethics

 - Language

3. Infrastructure

 - Physical facilities put in place by the region, business environment and laws enacted by government.

 - Legal framework

 - Transportation

 - Living costs

 - Rental costs

 - Stability

4. Construction

 - Land cost

 - Construction labour

 - Land preparation

 - Expansion possibilities

 - Construction materials availability

 - Zoning regulations

5. Factors affecting cash flow

 - Fluctuating exchange rate

 - Terms of operations

6. Financial aids

 - Direct cash grants or tax incentives on land, operations or products produced

7. Proximity of resources

 - Locating plants close to raw materials is critical e.g. oil refineries etc.

 - Reliable power supply is very important

8. Quantitative approaches

 - 4 Methods namely;

 i) Weighting the site criteria

 ii) Break-even analysis

 iii) Probability analysis

 iv) Centre of gravity method

**Chapter 8 - Supply Chain Management**

Supply chain management is the control inventory by managing the flow of materials.

An inventory is a stock of materials used to satisfy customer demand or support the production of goods or services.

3 types of materials;

1) Raw Materials: Needed for production of goods and services

2) Work-In-Process Materials: Items needed for the transformation process

3) Finished goods

A firm's finished goods may be another firm's raw material.

Organizations are becoming more conscious about the need to manage the flow of materials.

Materials are purchased from suppliers and their value represent a substantial value of the organization's income.

Organizations can make more profit by reducing the cost of the materials.

**Materials Management**

Materials management is concerned with decisions about purchasing materials and services, inventories, production levels, staffing, patterns, schedules and distribution.

Operations and logistics therefore play a major role in supply chain management.

Materials management is made up 3 roles;

- Purchasing

- Production control

- Distribution.

Purchasing: They are in charge of supplies and inventories of raw materials.

Production and control: Scheduling of machines and workers.

Distribution: Flow of materials to customers. It handles inventory of finished goods and services and transportation.

Materials Management can use 3 types of structure;

**Segmented structure:** Here, the managers of each department report to a different person.

It requires a great deal of co-ordination in order for it to achieve a competitive supply system.

**Integrated structure:** This centralizes material management task into one department. The manager of the department is elevated to a higher position in the organization.

This structure elevates the materials management function.

**Hybrid structure:** 2 functions report to materials management manager while distribution reports to the marketing manager.

**Supply chain**

It is the inter-connected set of linkages between suppliers of raw materials and services that spans the transformation of raw materials into products and services, and delivers them to a firm’s customers.

It can be very complicated

Suppliers can be controlled in 2 ways;

1) Having controlling interest in the firm's major supplier

2) By agreement

**Purchasing**

It is the management of the acquisition process, and it involves deciding, decoding which suppliers to use, negotiating contracts, as well as deciding whether to buy locally.

**Acquisition process**

1) Recognize the need

2) Select Supplier

3) Place order

4) Track order

5) Receive order

**Criteria for selecting suppliers**

The eyes of the organization in the suppliers marketplace is the purchasing department.

There is need to review current suppliers performance.

Suppliers certification is necessary.

3 criteria in selection[Price, Quality & Delivery]

**Types and effects of a supplier relations**

1) Competitive relationship

2) Co-operative relationship

**Distribution**

It is the management of the flow of materials from manufacturers to customers and from warehouses to retailers, involving the storage and transportation of products.

1) Where to stock finished goods;

2) What transportation mode to use[Highway, Rail, Water, Air and Pipeline]

3) How to schedule, route, and select carriers [Complex, Tradeoff between transportation cost and customer response time]

**Inventory measures**

**Chapter 9 - Inventory management**

Inventory is a stock or store of goods.

**Purpose of Inventories**

1. To meet anticipated demand or planned demand.

2. To smooth production requirements.

3. To decouple components of the production distribution system.

4. To protect against stock-outs, that is, one can reduce the risk of shortages.

5. To allow economic production and purchase or to take advantage of order cycles.

6. To hedge against price increases or to take advantage of quantity discounts

7. To permit operations.

**Inventory cost structure**

It comprises of 3 types;

1) Item cost: Cost of buying or producing the inventory item.

2) Ordering cost: Cost of ordering and receiving inventory e.g. expedite cost, delivery cost etc

3) Carrying cost: Cost associated with storing items for a period.

 It has 3 components [cost of capital, cost of storage & cost of deterioration]

**Independent Versus Dependent demand**

1) Dependent demand items: Used as component parts in the production of the finished product.

2) Independent Demand items: Finished goods

The nature of demand leads to these 2 different philosophies inventory management.

**Requirements for effective inventory**

Inventory has 2 basic functions

1) Keeping track of items

2) Making a decision about how much and when to order

The requirements are;

1. A system to keep track of the inventory on hand and on order.[Inventory counting system].It can be periodic or perpetual.

2. A reliable forecast of demand that includes an indication of possible forecast error.

3. Knowledge of lead times and head time and lead time variability.

4. Reasonable estimates of inventory holding costs, ordering costs and shortage costs.

5. A classification system for inventory items.

**Economic Order quantity model**

The question of how much to order is frequently determined by using economic order quantity (EOQ) models. EOQ models identify the optimal order quantity in terms of minimizing order costs. These models can take the following forms:

1. The economic order quantity model

2. The quantity discount model

3. The economic order quantity model with no instantaneous delivery

**Basic Economic Order Quantity Model**

D = Demand per year

S = Ordering cost

H = Carrying cost

**Chapter 10 - Aggregate planning**

Aggregate planning is the intermediate range of capacity planning that typically covers a time horizon of 2 to 12 month.

In some organizations, this time horizon might be extended to as much as 18 months.

It is useful for organizations that have fluctuation in demand or capacity.

The goal is to achieve a production plan that will effectively utilize organizational resources to satisfy expected demand.

It develops medium range production plan concerning staffing, inventory, facilities, orders and sub-contracting.

It imposes constraints on short-term plans.

**Concept of aggregation**

It focuses on a group of products or product line.

It thinks of capacity in terms of output rates.

**Purpose of aggregate planning**

The major purpose of aggregate planning is to develop a feasible production plan on an aggregate level that achieves a balance of expected demand and supply.

Furthermore, planners are usually concerned with minimizing the cost of the production plan. However, cost is not the only consideration.

Generally, aggregate planning is necessary in Production and Operations Management because it provides for:

(i) Fully loaded facilities and minimizes over-loading and under-loading, thereby reducing production costs.

(ii) Adequate production capacity to meet expected aggregate demand.

(iii) A plan for the orderly and systematic change of production capacity to meet the peaks and valleys of expected customer demand.

(iv) Getting the most output for the amount of resources available, which is important in time of scarce production resources.

**Inputs to Aggregate Planning**

For an effective aggregate planning to take place, at least three important informational needs must be met.

1) The available resources over the planning period must be known.

2) A forecast of expected demand must also be available.

3) Planners much take into account any policies regarding changes in employment levels.

Added to these inputs are the costs of activities, such as inventory carrying costs, general costs of backorders, hiring/firing, overtime, inventory changes and subcontracting.

**Demand and Capacity Options**

Demand options are;

1) Pricing

2) Promotion

3) Back orders

4) New demand

Capacity Options are;

1) Hire and Fire Workers

2) Overtime/Slack time

3) Part time workers

4) Inventories

5) Sub-contracting

**Basic strategies for Meeting Uneven Demand**

1. Maintaining a level workforce

2. Maintaining a steady output rate

3. Matching demand period by period

4. Using a combination of decision variables.

**How to choose a strategy**

It is affected by company's policy. Sub-contracting may not be allowed.

**Analytical techniques for aggregate Planning**

These are broadly placed into one of two categories;

- Informal trial and error techniques

- Mathematical techniques

The informal techniques are more widely used. The steps are;

1. Determine demand for each product.

2. Determine capacities (regular time, overtime, subcontracting) for each period.

3. Identify company or departmental policies that are pertinent. (e.g. maintain a safety stock of 5 percent of demand, maintain a reasonably stable workforce).

4. Determine unit costs for regular time, overtime, subcontracting, holding inventories, back orders, and other relevant costs.

5. Develop alternative plans and compute the costs for each.

6. If satisfactory plans emerge, select the one that best satisfies objectives. Otherwise, return to step 5.

Formal Techniques are;

1) Linear programming

2) Linear Decision Rule

3) Simulation model

**Disaggregating the Aggregate Plan**

There is the need to disaggregate the aggregate plan so that the production plan might be translated into meaning terms for production. This generally involves breaking down the aggregate plan into specific product requirements in order to determine labour requirements (skill, size of work force), materials and inventory requirements.

It is a fact that working with aggregate units often facilitates intermediate planning. However, for the production plan to be put into operation, those aggregate units must be decomposed into units of actual products or services that are to be produced or offered.

The result of disaggregate the aggregate plan is a master schedule, showing the quantity and timing of specific and items for a schedule horizon (Which often covers about six to eight weeks ahead). The master schedule shows demand for individual products rather than an entire product group, along with the timing of production. The master schedule usually contains important information for marketing as well as for production. It reveals when orders are scheduled for production and when completed orders are to be shipped.

**Chapter 11-Linear Programming**

In many business situations, resources are limited while demand for them is unlimited.

Linear programming (LP) is a method. It is useful for allocating scarce resources among competing demands. The resources may be time, money, or materials, and the limitation are known as constraints. Linear programming can help managers find the best allocation solution and provide information about the value of additional resources.

**Functions of LP**

1. LP is useful in the specification of optimum organisation of resources in a business organisation such that net returns of maximization of returns is achieved under given condition of resource restriction.

2. LP makes long range planning possible in business

3. LP gives technical co-efficient based largely on the practices and methods of operation adopted by the manager.

4. By-product obtained from results of the LP planning exercises are capable of throwing considerable light on a number of aspects of business management e.g. the surplus or unexhausted resource(s), the rate of interest the manager can justifiably pay on borrowed funds,

wages that the manager is willing to pay for labour.

**Characteristics of LP**

1. Linearity:- This implies that the input-output co-efficient are constant and independent of the scale of operation implying constant resource productivity and return to scale.

2. Additivity:- This assumption implies that the total quantity of resources used in different activities is equal to the sum of the quantities of different input used in each activity and that the size of any activity is independent of the size of other activities.

3. Divisibility:- This means that inputs are infinitely divisible. Thus, an LP solution can specify inputs and outputs in fractional units such as 10.7 units of labour etc.

4. Finiteness:- This implies that a limit exists on the number of `activities and resources which can be programmed. This is a practical assumption in the sense that an unlimited number of activities and resources would make an optimum solution impossible to obtain

5. Single valued expectation:- This characteristics shows that the prices of inputs and outputs, the input-output co-efficient and the levels of resources are known with certainty. Hence, a LP model is deterministic.

6. Non -negativity of decision variables:- This is very logical, there is no way you use any negative quantity of any resource, the least you use of any input among series of inputs in a production process is zero i.e. not used at all.

**Components of LP**

1. An objective function:- This must be clearly spelt out in mathematical language, and this can take one of several forms e.g. (a) Maximization of net revenue or profit from one or a several combination of enterprises (b) Maximization of production or a transportation cost.

2. Competitive enterprises with possible alternative methods of producing each enterprise. This implies that enterprises must be competing for the use of resources and in which case there is a problem of choice among enterprises.

3. Constraint to the attainment of the objective: A linear programming (LP) problem exists only if there are constraints limiting the attainment of an objective

Basically there are 3 types of constraints

1. Resource constraint:- A manager always have limited levels of such resources as capital, labour, machines, building capacity etc. which limits the scale of his operation.

2. Institutional constraint: - This is typified by quota system which is a contractual arrangement with say a governmental agency specified minimum or maximum production levels.

3. Subjective constraint: - The manager imposes this on himself. For example, there may be internal capital rationing due to (i) debt aversion (ii) scale restriction due to skill (iii) consumption habit consideration etc.

**Formulating a LP problem**

Step 1: Define the decision variable

Step 2: Write out the objective function.

Step 3. The final step is to formulate the constraints.

**Solution of the LP problem**

1. *Graphical analysis*

With the model formulated, we now seek the optimal solution. In practice, most linear programming problems are solved with the computer. However, insight into the meaning of the computer output and linear programming concept in general can be gained by analyzing a two - variable problem with the graphic method of linear programming, even though it isn't a practical

techniques for solving problems having three or more decision variables.

Five basic steps involved are;

1. Plot the constraint

2. Identity the feasible region

3. Plot an objective function line

4. Find the visual solution

5. Find the algebraic solution

Slack and surplus variables:

For a O constraints, the amount by which the left-hand side falls short of the right-hand side is called slack. For a 1:1 constraint, the amount by which the left-hand side exceeds the right-hand side is called surplus.

Sensitivity analysis

The parameters in the objective function and constraints are rarely known with certainty. Sometimes they are just estimates of actual values.

In spite of these uncertainties, initial estimates are needed to solve the problem. Accounting, marketing and work-standard information systems usually often provide these initial estimates. After solving the problem using these estimated values, the analyst can determine how much the optimal value of the decision variables and the objective function value Z would be affected if certain parameters had different values. This type of post solution analysis for answering "what if' question is called sensitivity analysis.

Right - hand - side parameters

Now consider how a change in the right-hand-side parameter for a constraint may affect the feasible region and perhaps cause a change in the optimal solution.

The change in Z per unit of change in the value of the right-hand side parameter of a constraint is called the shadow price, which is the marginal improvement in Z caused by relaxing the constraint by one unit. Relaxations mean making the constraint or decrease it for an O restrictive, which involves increasing the right-hand-side for an O constraint. The shadow price also is the marginal loss in Z caused by making the constraint more restrictive by one unit.

2. *Computer solution*

Most real-world linear programming problems are solved on a computer, so we will focus our understanding on the use of computer to solving LP problems and the logic behind its use. The solution procedure in computer codes is some form of the simplex method, an iterative algebraic procedure for solving linear programming problems.

Simplex Method

The graphic analysis gives insight into the logic of the simplex method. One corner point of the feasible region will always be the optimum, even when there are multiple optimal solutions. Thus, the simplex method starts with an initial corner point and then systematically evaluates other corner points in such a way that the objective function improves (or at worst, stays at the same) at each iteration.

Computer Output

Computer programmes diagrammatically reduce the amount of time required to solve linear programming problems. Special - purpose programmes can be developed for applications that must be repeated frequently. Such programmes simplify data input and generate the objective function and constraint for the problem.

**Dual**

The objective of any LP process is called the primal, the process of reversing or transpose of the primal process is called the dual. If the primal is to maximize then the dual is to minimize, whether the primal function is solved or its dual function is used to establish the solution, the answer remain unchanged.

*Procedure for a dual process*

1. Observe the objective function of the primal problem.

2. Write out the co-efficients of the constraints of the primal problem in form of matrix.

3. Transpose the matrix of co-efficients of the constraints.

4. Total requirement of each of the constraints of the primal problem now turn coefficients of the objective function of the dual.

5. Co-efficients of the objective function of the primal problem become the resource constraints.

6. The inequality sign is reversed for the dual problem.

**Chapter 12 - Material requirements planning(MRP)**

Material requirements planning (MRP) is a computer-based information system for ordering and scheduling of dependent-demand inventories (e.g. raw materials, component parts, and subassemblies).

Recall that dependent demand is the demand for items that are subassemblies or component parts to be used in the production of finished goods.

What is involved in MRP is the translation of a production plan for a specified number of finished products into requirements for component parts and raw materials working backward, using lead time information to determine when and how much to order.

MRP is as much a philosophy as it is a technique, and as much an approach to scheduling as it is to inventory control. MRP begins with a schedule of finished goods that is converted into a schedule of requirements for subassemblies, components parts, and raw materials needed to produce the finished items in the specified time frame.

What this amounts to, is that MRP is designed to answer three questions: What is needed? How much is needed? And when it is needed? The primary inputs of MRP necessary to answer these questions are (i) a bill of material, which tells the composition of a finished product; (ii) a master schedule which tells how much finished product is desired and when; and (iii) an inventory records file, which tells how much inventory is on hand or on order. This information is then processed to determine the planning horizon.

Outputs from the process include planned-order schedule, order releases, changes performance-control reports, planning repots and exception reports.

**MRP Inputs**

- The Master Schedule

- The Bill-of-Material File

- The Inventory Records File

*The Master Schedule*

The master schedule states which end items are to be produced, when they are needed, and in what quantities.

The quantities in a master schedule come from a number of different sources, including customer orders, forecasts, orders from warehouses to build up seasonal inventories, and external demand.

The master schedule separates the planning horizon into a series of time periods or time buckets, which are often expressed in weeks. However, the time bucket need not be of equal length.

It is important that the master schedule cover the stacked or cumulative lead time necessary to produce the end items. This cumulative lead time is the sum of the lead times that sequential phases of a process require, from ordering of parts or raw materials to completion of final assembly.

Stability in short-term production plans is very important; without it, changes in order quantity and/or timing can render material requirements plans almost useless. To minimize such problems, many firms establish a series of time intervals, called time fences, during which changes can be made to orders.

*The Bill-of-Material File*

A bill of materials (BOM) containing a listing of all the assemblies, subassemblies, parts, and raw materials that are needed to produce one unit of a finished product. This means that each finished product has its own bill of materials.

The listing in BOM is hierarchical; it shows the quantity of each item needed to complete one unit of the following level of assembly. The nature of this aspect of a BOM is perhaps grasped most readily by considering a product structure tree, which provides a visual depiction of the subassemblies and components that are needed to assemble a product.

A product structure tree is useful in illustrating how the bill of materials is used to determine the quantities of each of the ingredients (requirements) needed to obtain a desired number of end items.

*The Inventory Records File*

The inventory records file is used to store information on the status of each item by time period. This includes gross amount on hand. It also includes other details for each item, such as supplier, lead time, and lot size - changes due to stock receipts and withdrawal, canceled orders, and similar events also are recorded in this file.

**MRP Processing**

MRP processing takes the end-item requirements specified by the master schedule and "explodes" them into time-phased requirements for assemblies, parts, and raw materials using the bull of materials offset by lead times.

The quantities that are generated by exploding the bill of materials are gross requirements. It is the total expected demand for an item or raw material during each time period without regard to the amount on hand. For end items, these quantities are shown in the master schedule; for components, these quantities equal the planned-order releases of their immediate "parents".

*Scheduled Receipt: -* Open orders scheduled to arrive from vendors or elsewhere in the pipeline by the beginning of a period.

*Projected on hand: -* The expected amount of inventory that will be on hand at the beginning of each time period; schedule receipts plus available inventory from last period. Net-requirements: - The actual amount needed in each time period.

*Planned-order receipts: -* The quantity expected to be received by the beginning of the period in which it is shown. Under lot-for-lot ordering, this quantity will equal net requirements. Under lot-size ordering this quantity may exceed net requirements. Any excess is added to available inventory in the next time period.

*Planned-order releases: -* Indicates a planned amount to order in each time period; equal planned-order receipts offset by lead time. This amount generates gross requirements at the next level in the assembly or production chain. When an order is executed, it is removed from "planned-order releases" and entered under "Scheduled receipts"

*Updating the System:-*The two basic systems to update MRP records are regenerative and net change. A regenerative system is updated periodically; a net-change system is continuously updated.

A regenerative system is essentially a batch-type system, which compiles all changes (e.g. new orders, receipts) that occur within the time interval (e.g. week) and periodically updates the system. Using that information, a revised production plan is developed (if needed) in the same way that the original plan was developed (e.g. exploding the bill of materials level by level).

In a net-change system, the basic production plan is modified to reflect changes as they occur. If some defective purchased parts had to be returned to a vendor, this information is entered into the system as soon as it becomes known. Only the changes are exposed through the system, level by level; the basic plan would not be regenerated.

The regenerative system is best suited to fairly stable systems, whereas the net change system is best suited to systems that have frequent changes. The obvious disadvantage of a regenerative system is the potential amount of lag between the time information becomes available and the time it can be incorporated into the material requirements plan.

On the other hand, processing costs are typically less using regenerative systems; changes that occur in a given time period could ultimately cancel each other, thereby avoiding the need to modify and then re-modify the plan. The disadvantages of the net-change system relate to the computer processing costs involved in continuously updating the system and the constant state of flux in a system caused by many small changes. On way around this is to enter minor changes periodically and major changes immediately. The primary advantage of the net-change system is that management can have up-to-date information for planning and control purposes.

**MRP Outputs**

MRP systems have the ability to provide management with a fairly broad range of outputs. These are often classified as primary reports, which are the main reports, and secondary reports, which are optional outputs.

- Primary reports

- Secondary reports

*Primary Reports*

Production and inventory planning and control are part of primary reports. These reports normally include the following:

1. Planned orders, a schedule indicating the amount and timing of future orders.

2. Order releases, authorizing the execution of planned orders.

3. Changes to planned orders, including revisions of due dates or order quantities and cancellations of orders.

*Secondary Reports*

Performance control, planning, and exceptions belong to secondary reports.

1. Performance-control repots are used to evaluate system operation. They aid managers by measuring deviations from plans, including missed deliveries and stock-outs, and by providing information that can be used to assess cost performance.

2. Planning reports are useful in forecasting future inventory requirements. They include purchase commitments and other data that can be used to assess future material requirements.

3. Exception reports call attention to major discrepancies such as late and overdue orders, excessive scrap rates, reporting errors and requirements for none existent parts. The wide range of output generally permits users to adapt MRP to their particular needs.

Safety Stock

Theoretically, inventory systems with dependent demand should not require safety stock below the end-item level. This is one of the main advantages of an MRP approach. Supposedly, safety stock is not needed because usage quantities can be projected once the master schedule has been established.

Practically, however, there may be exceptions. For example, a bottleneck process or one with varying scrap rates can cause shortage in downstream operations. However, a major advantage of MRP is lost by holding safety stock for all lower-level items. When lead times are variable, the concept of safety time instead of safety stock is often used. This results in scheduling orders for arrival or completion sufficiently ahead of the time they are needed in order to eliminate or substantially reduce the element of chance in waiting for those items. Frequently, managers elect to carry safety stock for end items, which are subject to random demand and for selected lower-level operations when safety time is not feasible.

Lot Sizing

Choosing a lot size to order or for production is an important issue in inventory management for both independent- and dependent-demand items. This is called lot sizing. For independent-demand items, economic order sizes and economic run sizes are often used.

Mangers can realize economies of scale by grouping order or run sizes. This would be the case if the additional cost in covered by holding extra units until they were used led to a saving in set up or ordering cost. This determination can be very complex at times. Some of the methods used to

handle lot sizing are;

- Lot-for-lot ordering

- Economic Order Quantity Model

- Fixed - Period Ordering

- Part-Period Model

Capacity Requirements Planning

One of the most important features of MRP is its ability to aid manager in capacity planning. As noted, a master production schedule that appears feasible on the surface may turn out to be far less feasible in terms of the resources requirements needed for fabrication and /or subassembly operations of lower level items.

Capacity requirement planning is the process of determining shortage capacity requirements. The necessary inputs include planned-order releases for MRP, the current shop load, routing information and job times.

Outputs include load report for each work center. When variances (under loads or over loads) are projected, managers might consider remedies such as alternative routing, changing or eliminating lot splitting. Moving production forward or back ward can be extremely challenging because of precedence requirements and availability of components.

The capacity planning begins with a proposed or tentative master production schedule that must be tested for feasibility and possibly, adjusted before it becomes permanent. The proposed schedule is processed using MRP to ascertain the material requirements the schedule would generate. These are then translated into resource (i.e. capacity) requirements often in the form of a series of load reports for each department or work p center, which compares known and expected future capacity requirement with projected capacity availability.

An important aspect of capacity requirements planning is the conversion of quantity requirements into labour and machine requirements. This is accomplished by multiplying each period's quantity requirements by standard labor and/or machine requirements per unit.

**Benefits of MRP**

MRP offers a number of benefits for the typical manufacturing or assembly type of operation, including:

(1) Low levels of in-process inventories

(2) The ability to keep track of material requirements.

(3) The ability to evaluate capacity requirements generated by a given

master schedule.

(4) A means of allocating production time.

A range of people in a typical manufacturing company are important users of information provided by an MRP system. Production mangers who must balance workloads across departments and make decisions about scheduling work, and plant foremen, who are responsible for issuing work orders and maintaining production schedules, also rely heavily on MRP output.

Other users include customer service representatives, who must be able to supply customers with projected delivery dates, purchasing managers, and inventory managers. The benefits of MRP depend on large measure on the use of a computer to maintain up-to-date information on material requirements.

**Requirements of MRP**

In order to implement and operate an effective MRP system, it is necessary to have:

(1) A computer and the necessary software programs to handle computations and maintain records.

(2) Accurate and up-to-date

(a) Master schedule

(b) Bills of materials

(c) Inventory records

(3) Integrity of file data

On the whole, the introduction of MRP has led to a major improvement in scheduling and inventory management but it has not proved to be the cure-all that many hoped it would be.

Consequently, manufacturers are beginning to take a much broader approach to resource planning one such approach is referred to as MRP 2.

**MRP 2**

MRP 2 refers to manufacturing resources planning. It represents an effort to expand the scope of production resource planning and to involve other functional areas of the firm in the planning process.

A major purpose of MRP is to integrate primary functions and other functions such as personnel,

engineering and purchasing in the planning process.

Material requirement planning is at the heart of the process. Process begins with an aggregation of demand from all sources (e.g. firm orders, forecasts, safety stock requirement). Production, marketing and finance personnel work toward developing a master production schedule.

Although manufacturing people will have a major input in determining the schedule and a major

responsibility for making it work, marketing and finance will also have important inputs and responsibilities. The rationale for having these functional areas work together is the increase likelihood of developing a plan that works and with which everyone can live. Moreover, because each of these functional areas has been involved in formulating the plan, they will have reasonably good knowledge of the plan and more reason to work toward achieving it.

In addition to the obvious manufacturing resources needed to support the plan, financing resources will be needed and must be planned for, both in amount and timing. Similarly, marketing resources will also be needed in varying degree throughout the process. In order for the plan to work, all of the necessary resources must be available as needed. Often, an initial plan must be revised based on an assessment of the availability of various resources. Once these have been decided, the master production schedule can be firmed up.

At this point, material requirement planning comes into play generating material and schedule requirements. More detailed capacity requirement planning must be made next to determine whether these more specific requirements can be met. Again some adjustment in the master production schedule may be required.

As the schedule unfold, and actual work begins, a variety of reports help managers to monitor the process and to make any necessary adjustments to keep operations on track.

In effect, this is a continuing process where the master production schedule is updated and revised as necessary to achieve corporate goals. The business plan that governs the entire process usually undergo changes too although this tend to be less frequent than the changes made at lower levels (i. e. the master production schedule).

Finally, it should be noted that most MRP 2 systems have the capability of performing simulation, enabling managers to answer a variety of "what if” questions so they can gain a better appreciation of available options and their consequences.

**Chapter 13 - Just In time systems (JIT)**

The term just-in-time (JIT) is used to refer to a production system in which both the movement of goods during production and deliveries from suppliers are carefully timed so that at each step of the process the next (usually small) batch arrives for processing just as the preceding batch is complete-thus, the name just-in-time. The result is a system with no idle items waiting to be processed and no idle workers or equipment waiting for items to process.

The just-in-time phenomenon is characteristic of lean production system, which operates with very little "fat" (e.g. excess inventory, extra workers, and wasted space). JIT pertains to the timing of the flow of parts and material through the systems, and the timing of services.

Companies that employ the JIT/lean production approach have lower processing costs, fewer defectives, and greater flexibility; and are able to bring new or improved products to the market more quickly.

The JIT approach was developed at the Toyota Motor Company of Japan by Taiichi Ohno (who eventually became vice president of manufacturing) and several of his colleagues. JIT regards scrap and rework as waste, and inventory as an evil because it takes up space and ties up resources.

JIT represents a philosophy that encompasses every aspect of the process, from design to after the sale of a product. The philosophy is to pursue a system that functions well with minimal levels of inventories, minimal space, and minimal transactions. It must be a system that is not prone to disruptions and is flexible in terms of the product variety and range of volume that it can handle. The ultimate goal is to achieve a balanced system that permits a smooth, rapid flow of materials through the systems.

Companies that use JIT have achieved a level of quality that enables them to function with small batch sizes and tight schedules. JIT systems have high reliability: major sources of inefficiency and disruption have been eliminated, and workers have been trained not only to function in the system but also to consciously improve it.

**JIT Goals**

The ultimate goal of JIT is a balanced system; that is, one that achieves a smooth, rapid flow of materials through the system. The idea is to make the process time as short as possible by using resources in the best possible way. The degree to which the overall goal is achieved depends on how well certain supporting goals are achieved. These goals are:

1. Eliminate disruptions.

2. Make the system flexible.

3. Reduce setup times and lead times

4. Minimize inventory.

5. Eliminate waste.

Disruptions are caused by a variety of factors, such as poor quality, equipment breakdowns, changes to the schedule and late deliveries. These should be eliminated as much as possible. Inefficiency and disruption have been eliminated, and workers have been trained not only to function in the system but also to consciously improve it.

A flexible system is one that is robust enough to handle a mix of products, often on a daily basis, and to handle changes in the level of output while still maintaining balance and throughput speed.

Setup times and delivery lead times prolong a process without adding any value to the product. Moreover, long setup times and long lead times negatively impact the flexibility of the system. Hence, reduction of setup and lead times is important, and is one objective of continuous improvement.

Inventory is an idle resource, taking up space and adding cost to the system. It should be minimized or even eliminated wherever possible. Waste represents unproductive resources: eliminating waste can free up resources and enhance production. In the JIT philosophy, waste includes.

• Overproduction

• Waiting time

• Unnecessary transporting

• Inventory storage

• Scrap

• Inefficient work methods

• Product defects

The existence of these wastes is an indication that improvement is possible.

Alternatively, the list of wastes identifies potential targets for continuous improvement efforts.

**Building Blocks**

The design and operation of a JIT system provide the foundation for accomplishing the aforementioned goals. The foundation is made up of four building blocks:

1. Product design

2. Process design

3. Personnel/organizational elements

4. Manufacturing planning and control.

*Product design*

Three elements of product design are key to JIT systems:

1. Standard parts

2. Modular design

3. Quality

The first two elements relate to speed and simplicity. The use of standard parts means that workers have fewer parts to deal with, and training times and costs are reduced. Purchasing, handling, and checking quality are more routine and lend themselves to continual improvement.

Another importance benefit is the ability to use standard processing.

Modular design is an extension of standard parts. Modules are clusters of parts treated as a single unit. This greatly reduces the number of parts to deal with, simplifying assemble, purchasing, handling, training, and so on.

Standardization has the added benefit of reducing the number of different parts contained in the bill of materials for various products, thereby simplifying the bill of materials.

Disadvantage of standardization are less product variety and resistance to change in a standard design. These disadvantages are partly offset where different products have some common parts or modules. Using a tactic that is sometimes referred to as delayed differentiation; a decision concerning which products will be produced can be delayed while the standard portions are produced. When it becomes apparent which products are needed, the system can quickly respond by producing the remaining unique portions of those products.

Quality is the sine qua non (“without which not" ) of JIT. It is crucial to JIT systems because poor quality can create major disruptions.

JIT system uses a three-part approach to quality: One part is to design quality into the product and the production process. High quality levels can occur because JIT systems produce standardized products that lead to standardized job methods, workers who are very familiar with their jobs, and the use of standardized equipment.

Moreover, the cost of product design quality (i.e., building quality in at the design stage) can be spread over many units, yielding a low cost per unit. It is also important to choose appropriate quality levels in terms of the final customer and of manufacturing capability: Thus, product design and process design must go hand in hand.

*Process Design*

Seven aspects of product are particularly important for JIT systems:

(1) Small lot sizes

(2) Setup time reduction

(3) Manufacturing cells

(4) Limited work in process

(5) Quality improvement

(6) Production flexibility

(7) Little inventory storage

Small lot sizes in both the production process and deliveries from suppliers yield a number of benefits that enable JIT systems to operate effectively: First, with small lots moving through the systems, in-process inventory is considerably less that it is with large lots. This reduces carrying costs, space requirements, and clutter in the workplace. Second, inspection and rework costs are less when problems with quality occur, because there are fewer items in a lot to inspect and rework.

Small lots also permit greater flexibility in scheduling. This flexibility enables JIT systems to respond more quickly to changing customer demands for output: JIT systems can produce just what is needed, when it is needed.

Small lots and changing product mixes require frequent setups. Unless these are quick and relatively inexpensive, the time and cost to accomplish them is prohibitive. Often, workers are trained to do their own setups. Moreover, programs to reduce setup time and cost are used to achieve the desired results; a deliberate effort is required, and workers are usually a valuable part of the process.

One characteristic of many JIT systems is multiple manufacturing cells. The cells contain the machine and tools needed to process families of parts having similar processing requirements. In essence the cells are highly specialized and efficient production centres. Among the important benefits of manufacturing cells are reduced changeover times, high utilization of equipment, and ease of cross-training operators. The combination of high cell efficiency and small lot sizes results in very little work-in-process inventory.

JIT systems sometimes minimize defects through the use of autonomation (note the extra syllable ‘no’ in the middle of the word). This refers to the automatic detection of defects during production. It can be used with machines or manual operations. It consists of two mechanisms: one for detecting defects when they occur and another for stopping production to correct the cause of the defects. Thus, the halting of production force immediate attention to the problem, after which an investigation of the problem is conducted, and corrective action is taken to resolve the problem.

Because JIT systems have very little in-process inventory, equipment breakdowns can be extremely disruptive. To minimize breakdowns, companies use preventive maintenance programs, which emphasize maintaining equipment in good operating condition and replacing parts that have a tendency to fail before they fail. Workers are often responsible for maintaining their own equipment.

Guidelines for increasing production flexibility are as follows:

1. Reduce downtime due to changeovers by redoing changeovers time

2. Use preventive maintenance on key equipment to reduce breakdowns and downtime.

3. Cross-train workers so they can help when bottlenecks occur or other

workers are absent. Train workers to handle equipment adjustments and minor repairs.

4. Use many small units of capacity: many small cells make it easier than a few units of large capacity to shift capacity temporally and to add or subtract capacity.

5. Use off-line buffers. Store infrequently used safety stock away from the production area to decrease congestion and to avoid continually turning it over.

6. Reserve capacity for important customers.

One way to minimize inventory storage in a JIT system is to have deliveries from suppliers go directly to the production floor, which completely eliminates the need to store incoming parts and materials. At the other end of the process, completed units are shipped out as soon as they are ready, which minimize storage of finished goods. Coupled with low work-in-process inventory; these features result in systems that operate with very little inventory.

Among the advantages of lower inventory are less carrying cost, less space needed, less tendency to rely on buffers, less rework if defects occur, and less need to "work off' current inventory before implementing design improvements. But carrying fewer inventories also has some risks. The primary one is that if problems arise, there is no safety net. Another is that opportunities may be lost if the system is unable to respond quickly enough.

*Personnel Organizational Elements*

There are five elements of personnel and organizational that are particularly important for JIT systems:

1. Workers as assets.

2. Cross-trained workers

3. Continuous improvement

4. Cost accounting

5. Leadership project management.

Worker as Assets:- A fundamental tenet of the JIT philosophy is that workers are assets. Well-trained and motivated workers are the heart of a JIT system. They are given more authority to make decisions than their counterparts in more tradition systems, but they are also expected to do more.

Cross-Trained Worker:- Worker are cross-trained to perform several parts of a process and operate a variety of machines. This adds to system flexibility because workers are able to help one another when bottlenecks occur or when a co-worker is absent.

Continuous Improvement:- Workers in a JIT system have greater responsibly for quality than worker in traditional systems, and expected to be involved in problem solving and continuous improvement. JIT workers typically receive extensive training in statistical process control, quality improvement, and problem solving.

Problem solving is a cornerstone of any JIT interest are problems that interrupt, or have the potential to interrupt, the smooth flow of work through the system. A central theme of a true just-in-time approach is to work toward continual improvement of the system-reducing inventories, reducing setup cost and time, improving quality; increasing the output rate, and generally cutting waste and inefficiency. Toward that end, problem solving becomes a way of life a "culture" that must be assimilated into the thinking of management and workers alike. It becomes a never ending quest for improving operations as all members of the organization strive to improve the system.

Cost Accounting:- Another feature of some JIT systems is the method of allocating overhead. Traditional accounting methods sometimes distort overhead allocation because they allocate it on the basis of direct labour hours.

However, that approach does not always accurately reflect the consumption of overhead by different jobs.

One alternative method of allocating overhead is activity-based costing. This method is designed to more closely reflect the actual amount of overhead consumed by particular job or activity.

Activity-based costing first identifies traceable costs and then assigns those costs to various types of activities such as machine setups, inspection, machine hours, direct labour hours, and

movement of material. Specific jobs are then assigned overhead based on the percentage of activities they consume.

Leadership/Project Management:- Another feature of JIT systems relates to leadership. Managers are expected to be leaders and facilitators, not order givers. Two-way communication between workers and managers is encouraged.

Project managers are often given full authority over all phases of a project. They remain with the project from beginning to end; in the more traditional forms of project management, the project manger often has to rely on the cooperation of other managers to accomplish project goals.

**Manufacturing Planning and Control**

Five elements of manufacturing planning and control are particularly important for JIT systems:

1. Level loading

2. Pull system

3. Visual system

4. Close vendor relationships

5. Reduced transaction processing

Level Loading:- JIT systems place a strong emphasis on achieving stable level daily mix schedules. Toward that end, the master production schedule is developed with level capacity loading. That may entail a rate-based production schedule instead of the more familiar quality -based schedule. Moreover, once they are established, production schedules are of short time horizon, which provide certainty to the system. This is needed in day-to-day schedules to achieve level capacity requirements.

Pull Systems:- The terms push and pull are used to describe two different systems for moving work through a production process. In push systems, when work is finished at a workstation, the output is pushed to the next station: or, in the case of the final operation, it is pushed on to final inventory Conversely, in a pull system, control of moving the work rests with the following operation: Each workstation pull the output from the preceding station as it is needed; output of the final operation is pulled by customer demand or the master schedule. Thus, in a pull system, work is moved response to demand from the stage in the process, whereas in push system, work is pushed in as it is completed, without regard to the next station’s readiness for the work.

Consequently, work may pile up at workstations that fall behind schedule because of equipment failure or the detection of a problem with quality. JIT systems use the pull approach to control the flow of work, with each workstation gearing its output to the demand presented by the next workstations. Traditional production systems use the push approach for moving work through the system. JIT system communication moves backward through the system from station to station. Work moves "just in time" for the next operation; the flow of work is thereby coordinated, and the accumulation of excessive inventories between operations is avoided. Of course, some inventory is usually present because operations are not instantaneous

Visual Systems:- Another way to describe the pull system is that work flow is dictated by "next-step demand". Such demand can be communicated in a variety of ways, including a shout or a ware, but by far the most commonly used device is the kanban card. Kanban is a Japanese word meaning "signal" or "visible record". When a worker needs materials or work from the preceding station, he or she used a kanban card.

In effect, the kanban card is the authorization to move or work on parts. In Kanban system, no part or lot can be moved or worked on without one of these cards. The ideal number of Kanban cards can be computed using this formula:

N= DT(l+X) C

Where

N = Total number of containers

D = Planned usage rate of using work centre

T = Average waiting time for replenishment of parts plus average production time for a container of parts

X = Policy variable set by management that reflects possible inefficiency in the system (the closer to 0. the more efficient the system

C = Capacity of a standard container (should be no more than 10 percent of daily usage of the part).

Note that D and T must use the same time units (e.g., minutes, days).

Close Vendor Relationships: JIT systems typically have close relationship with vendors, who are expected to provide frequent small delivers of high quality goods. Traditionally, buyers have assumed the role of monitoring the quality of purchased goods, inspecting shipments for quality and quantity, and returning poor-quality goods to the vendor for rework. JIT systems have little slack, so poor-quality goods cause a disruption in the smooth flow of work.

Moreover, the inspection of incoming goods is viewed as inefficient because it does not add value to the product. For these reasons, the burden of ensuring quality shifts to the vendor. Buyers work with vendors to help them achieve the desired quality levels and to impress upon them the importance of consistent, high-quality goods. The ultimate goal of the buyers is to be able to certify a vendor as product A producer of high-quality goods. The implication of certification is that a vendor can be relied on to deliver high quality goods without the need for buyer inspection.

Suppliers must also be willing and able to ship in small lots on regular basis. Under JIT purchasing, good vendor relationships are very important. Buyers take measures to reduce their list to suppliers, concentrating on maintaining close working relationships with a few good ones. Because of the need for frequent, small delivers many buyers attempt to find local vendors to shorten the lead time for deliveries and to reduce lead time variability. An added

advantage of having vendors nearby is quick response when problems arise. Suppliers: A key feature of many lean production systems is the relatively small number of suppliers used. Lean production companies may employ a tiered approach for suppliers. They use relatively few first-tier suppliers who work directly with the company or who supply major subassemblies. The first tier suppliers are responsible for dealing with second-tier suppliers who provide components for the subassemblies, thereby relieving the final buyer from dealing with large numbers of suppliers.

A good example of this situation is found in the automotive industry. Suppose a certain model has an electric seat. The seat and motor together might entail 250 separate parts. A traditional producer might use more than 50 suppliers for the electric seat, but a lean producer might use a single (first-tier) supplier who has the responsibility for the entire seat unit. The company would provide specifications for the overall unit, but leave to the supplier the details of the motor, springs and so on. The first-tier supplier, in turn, might subcontract the motor to a second-tier supplier, the track to another second-tier supplier, and cushions and fabric to still another. The second-tier suppliers might subcontract some of their work to third-tier suppliers, and so on. In this "team of suppliers" approach, all suppliers benefits from a successful product, and each supplier bears full responsibility for the quality of its portion of the product.

Reduced Transaction Processing:- The transactions can be classified as logical, balancing, quality, or change transactions.

Logical Transactions:- Include ordering, execution, and confirmation of materials transported from one location to another. Related costs cover shipping and receiving personnel, expediting orders, data entry, and data processing.

Balancing transactions:- Include forecasting, production control, procurement, scheduling, and order processing. Associated costs relate to the personnel involve in these and supporting activities.

Quality transactions:- Include determining and communicating specifications, monitoring, recording, and follow-up activities. Costs relates to appraisal, prevention, internal failures (e.g., scrap, rework, retesting, delay, administration activities) and external failure (e.g., warranty cost, product liability, returns, potential loss of future business).

Change transactions:- Primarily involve engineering changes and the ensuing changes generated in specifications, bills of material, scheduling, processing instructions and so on. Engineering changes are among the most costly of all transactions.

JIT systems cut transaction costs by reducing the number and frequency of transactions. For example, supplier deliver goods directly to the production floor, by passing the store-room entirely, thereby avoiding the transactions related to receiving the shipment into inventory storage and later moving the materials to the production floor. In addition, vendors are certified for quality, eliminating the need to inspect incoming shipment for quality. The unending quest for quality improvement that pervades JIT systems eliminates many of the above mentioned quality transactions and their related costs. The use of bar coding (not exclusive to JIT systems) can reduce data entry transactions and increase data accuracy.

**Benefits of JIT Systems**

JIT systems have a number of important benefits that are attracting the attention of traditional companies. The main benefits are:

1. Reduced level of in-process inventories, purchased goods, and finished goods.

2. Reduced space requirements.

3. Increased product quality and reduced scrap and rework.

4. Reduced manufacturing lead times.

5. Greater flexibility I changing the production mix.

6. Smoother production flow with fewer disruptions caused by problems due to quality, shorter setup times, and multi-skilled workers who can help each other and substitute for other

7. Increased productivity levels and utilization of equipment

8. Worker participation in problem solving.

9. Pressure to build good relationships with vendors

10. Reduction in the need for certain indirect labour, such as material handlers.

**Chapter 14 - Project management (PM)**

Managers typically oversee a variety of operations. Some of these involve routine, repetitive activities, but other involves non routine activities. Under the non-routine are projects.

A project is a unique, one-time operations designed to accomplish a set of objectives in a limited time frame. e.g. constructing a shopping complex, drainage system, installing a new computer system, introducing a new product or service to the market place.

Projects may involve considerable cost. It has a long time horizon. Also, It involves a large number of activities that must be carefully planned and coordinated. Most are expected to be completed within time, cost, and performance guidelines. To accomplish these, goals must be established and priorities set. Tasks must be identified and time estimates made. Resource

requirements must also be projected and budget prepared. Once commenced, progress must be monitored to ensure that project goals and objectives are achieved.

**Behavioral aspect of Project Management**

Project management differs from management of more traditional activities which gives rise to a host of rather unique problems. This section will emphasize the nature of projects and their behavioral implications. Emphasis will be laid on the role of the project manager.

*The Nature of Projects*

Projects go through a series of stages, a life cycle, which include planning, execution, and project phase out. During this life cycle, a variety of skillful requirements are involved.

In effect, projects unit personnel are with diverse knowledge and skills, most of whom remain together for less than the full life of the project. Some personnel go from project to project as their contributions become needed, some on a fulltime or part-time basis, from their regular jobs. Certain kinds of organisation tend to be involved with project on a regular basis; examples include consulting firms, architects, writers and publishers.

*The Project Manager*

The central figure in a project is the project manager. He or she bears the ultimate responsibility for the success or failure of the project manager. The role of the project is one of an organizer - a person who is capable of working through others to accomplish the objectives of the project.

Once the project is underway, the project manager is responsible for effectively managing each of the following:

1. The work, so that all of the necessary activities are accomplished in the desired sequence.

2. The human resource, so that those working on the project have direction and motivation.

3. Communications, so that everybody has the information they need to do their work.

4. Quality, so that performance objectives are realized

5. Time, so that the project can be completed on a time.

6. Costs, so that the project is completed within budget.

The job of project manager can be both difficult and rewarding. The manager must coordinate and motivate people who sometimes owe their loyal support to other managers in their functional areas. In addition, the people who work on a project frequently possess distinct knowledge and skill that the project manager lacks. Nevertheless, the manager is expected to evaluate and guide their efforts.

The rewards of the job of project manager come from the challenges of the job, the benefits of being associated with a successful project, and the personal satisfaction of seeing it through to its conclusion.

*The Merits and De-merits of Working on Projects*

People are chosen to work on special projects because the knowledge or abilities they possess are needed. In some instances, however, their supervisor may be unwilling to allow them to interrupts their regular jobs, even on a part time basis, because it may require training a new person to do a job that will be temporary.

Moreover, managers don't want to lose the output of good workers. The workers themselves are not always eager to participate in projects because it may mean working for two bosses who impose differing demands and may cause disruption of friendships and daily routines, and the risk of being replaced on the current job.

In spite of the potential risks of being involved in a project, people are attracted by the potential rewards. One is the dynamic environment that surrounds a project, often a marked contrast to the more staid environment in which some may feel trapped. Then, too, projects may present opportunities to meet new people and to increase future job opportunities, especially if the project is successful. In addition, association with a project can be a source of status among fellow workers.

**Project Life Cycle**

The length, size and scope of projects vary widely according to the nature and purpose of the project. Nevertheless all projects have something in common. They go through a life cycle, which typically consists of five phases.

1. Concept at which point the organisation recognizes the need for a project or responds to a request for a proposal from a potential client.

2. Feasibility analysis, which examines the expected costs, benefits and risk of undertaking the project.

3. Planning, this spells out the details of the work and provides estimates of the necessary human resources, time and cost.

4. Execution, during which the project itself is done. This phase often accounts for the majority of time and resources consumed by a project.

5. Termination, during which closure is achieved.

It should be noted that the phases can overlap, so that one phase may not be fully completed before the next phase begins. This can reduce the time necessary to move through the life cycle, perhaps generating some competitive advantage and cost saving.

**Work Breakdown Schedule**

Because large projects usually involve a very large number of activities, planners need some way to determine exactly what will need to be done so that they can realistically estimate how long it will take to complete the various elements of the project and how much it will cost. This is often accomplished by developing a work breakdown structure (WBS), which is a hierarchical listing of what must be done during the project. This methodology establishes a logical framework for identifying the required activities for the project. The framework is illustrated below. The first step in developing the work breakdown structure is to identify the major elements of the project.

The next step is to identify the major supporting activities for each of the major elements. Then,

each major supporting activity is broken down into a list of the activities that will be needed to accomplish it.

**Planning and Scheduling with Gantt Charts**

The Gantt chart is a popular tool for planning and scheduling simple projects. It enables a manager to initially schedule project activities and then to monitor progress over time by comparing planned progress to actual progress.

To prepare the chart, the personnel in charge of the project first identify the major activities that would be required. Next, time estimates for each activity is made, and the sequence of activities is determined. Once completed, the chart would indicate which activities will occur, their planned duration, and when they will to occur. Then, as the project progresses, the manager would be able to see which activities were ahead of schedule and which were delaying project.

This enables the manager to direct attention where it was needed most to hasten the project in order to finish on schedule.

The obvious advantage of a Gantt chart is its simplicity, and this accounts for its popularity. However, Gantt Charts fails to reveal certain relationships among activities that can be crucial to effective project management. For instance, if one of the early activities in a project suffers a delay, it would be important for the manager to be able to easily determine which later activities

would result in a delay.

**PERT and CPM**

PERM (Program Evaluation and Review Technique) and CPM (Critical Path Method) are two of the most widely used techniques for planning and coordinating large -scale projects. By using PERT and CPM, managers are to obtain:

1. A graphical display of project activities

2. An estimate of how long the project will take

3. An indication of which activities are the most critical to timely project completion.

4. An indication of how long any activities can be delayed without lengthening the project.

**The Network Diagram**

One of the main features of PERT and related techniques is their use of a network or precedence diagram to depict major project activities and their sequential relationships.

A network diagram for the same problem is composed of a number of arrows and nodes. The arrows represent the project activities. Note how much clearer the sequential relationship of activities is with a network chart than with a Gantt chart.

Hence, a network diagram is generally the preferred approach for visual portrayal of project activities.

There are two slightly different conventions for constructing these network diagrams. Under one convention, the arrows designate activities: under the other convention, the nodes designate activities. These conventions are referred to as activity - on- arrow (A-O-A) and activity –on-node (A-O-N), we will concentrate on the activity -on-arrow convention. For now, we shall use the arrows for activities. Activities consume resources and/or time. The nodes in the A-O-A approach represent the starting and finishing of activities, which are called events. Events are points in time. Unlike activities, they consume neither resources nor time.

Activities can be referred to in either of two ways. One is by endpoints and the other is by a letter assigned to an arrow. Both methods are illustrated in this unit. The network diagram describes sequential relationship among major activities on a project.

The path with the longest time is of particular interest because it governs project completion time. Project life cycle equals the expected time of the longest path; the longest path is referred to as the critical path, and its activities are referred to as critical activities. The allowable slippage for any path is called slack, and it reflects the difference between the length of a given path and the length of the critical path.

**Deterministic Time Estimates**

The main determinant of the way PERT and CPM networks are analyzed and interpreted is whether activity time estimates are probabilistic or deterministic. If time estimates can be made with a high degree of confidence the actual times will not differ significantly, we say the estimates are deterministic. If estimated times are subject to variation, we say the estimates are probabilistic.

Probabilistic time estimates must include an indication of the extent of probable variation.

Here, a description of analysis of networks with deterministic time estimates and probabilistic times are treated.

*A computing algorithm*

Many real-life project networks are much larger than the simple network illustrated in the preceding example; they often contain hundreds or thousands of activities. Because the necessary computations can become exceedingly complex and time -consuming, large networks are generally analyzed by computer programmes instead of being done manually. The intuitive approach just demonstrated does not lend itself to computerization because, in many instances, path sequences are not readily apparent. Instead, an algorithm is used to develop four pieces of information about the network activities:

ES, the earliest time activity can start, assuming all preceding activities start as early as possible. EF, the earliest time the activity can finish.

LS, the latest time the activity can start and not delay the project LF, the latest time the activity can finish and not delay the project

Once these values have been determined they can be used to find:

1. Expected project duration

2. Slack time

3. Those activities on the path

*Probabilistic time estimates*

The preceding discussion assumed that activity times were known and not subject to variation. While the assumption is appropriate in some situations there are many others where it is not. Consequently, those situations require a probabilistic approach.

The probabilistic approach involves three time estimates for each activity instead of one:

1. Optimistic time: - The length of time required under optimum conditions; represented by the letter o.

2. Pessimistic time: T he length of time required under the worst conditions: represented by the letter p.

3. Most likely time: The most probable amount of time required: represented by the letter m.

4. These time estimates can be made by managers or others with knowledge about the project.

The beta distribution is generally used to describe the inherent variability in time estimates.

Although there is no real theoretical justification for using the beta distribution, it has certain features that make it attractive in practice: the distribution can be symmetrical or skewed to either the right or the left according to the nature of a particular activity: the mean and the variance of the distribution can be readily obtained from the three times estimates listed above: and the distribution is unimodal with a high concentration of probability surrounding the most likely time estimate.

*Time-cost trade-offs: Crashing*

Estimates of activity times for projects usually are made for some given level resources. In many situations, it is possible to reduce the length of a project by injecting additional resources. The necessity to shorten projects may reflect efforts to avoid late penalties, to take advantage of monetary incentives for timely or early completion of a project. In new product development, shortening may lead to a strategic benefit: beating the competition to the market.

Managers often have certain options at their disposal that will allow them to shorten, or crash, certain activities. Among the most obvious options are the use of additional funds to support additional personnel or more efficient equipment and the relaxing of some work specifications.

In order to make a rational decision on which activities, if any to crash and on the extent of crashing desirable, a manager needs certain information.

1. Regular and time crash estimates for each activity.

2. A list of activities that are on the critical path

3. Regular cost and crash cost estimates for each activity.

Activities on the critical path are highly subjected to crashing, since shortening non critical activities would not have an impact on total project duration. From an economic standpoint, activities should be crashed according to crashing costs: crash those with lowest cost first.

Moreover, crashing should continue as long as the cost to crash is less than the benefits received from crashing.

**Chapter 15 - Productivity**

Productivity itself relates to how effective an organisation is in the use of its resource. There is a difference between efficiency and productivity.

**Productivity and Human Behaviour**

One of the primary responsibilities of an operations manager is to achieve productive use of an organisations resource.

The term "productivity" is used to describe this. Productivity is actually an index that measures output (i.e. goods and services) relative to the input (e.g. labour, materials, energy, cost of equipment, and other appropriate resources) used to produce them. It is usually expressed as the ratio of output to input

It can affect a single operation, department, organization, country etc.

It can be based on a single input or all the inputs.

The choice of a particular measure depends primarily on the purpose of measurement.

Examples of such measures include;

1. Labour productivity

2. Machine productivity

3. Capital productivity

4. Energy productivity

Productivity measures are of prime importance at different levels. For instance, in the case of an individual department or organization, such measures can be used to track performance over time this provides opportunities for operations managers to judge performance, and to decide where improvements are needed. Productivity can also be used to determine the performance of an entire industry or even the national productivity of country as a whole. In a nutshell, productivity measurements serve as scorecards of the effective use of resources.

Operations manager plays a key role in determining productivity. Their challenge is to increase the value of output, relative to the cost of input. For example, if they can generate more output of better quality by using the same amount of input productivity will definitely increase. Again if they can maintain the same level of output while reducing the use resources productivity will also increase.

At the national level, productivity is usually measured as the naira value of output per unit of labour. This measure depends on the quality of the products and services generated in a nation, as well as the efficiency with which they are produced.

Productivity is actually the prime determinant of a nation's standard of living. If the output per work hour goes up, the nation benefits from higher income levels, since the productivity of human resources determines employee wages.

On the other hand, lagging or declining productivity lowers the standard of living. For instance, wage or price increases not accompanied by productivity increases usually lead to inflationary pressures rather real increases in the standard of living.

**Labour Productivity**

Many companies today are pushing hard to improve their labour productivity. For many of these companies, direct labour cost remains a significant cost. Some manufacturing operations are not yet automated, and never will be because either it is not cost effective or insufficient capital is available. In addition, many services remain direct-labour-intensive. For these reasons, the cost of labour and the need to improve the productivity of labour continues to receive management attention.

Unfortunately, there are currently no sets of formulas that precisely predict human behaviour, in general and productivity in particular. It is however gratifying to note that we can have enough understanding of employee behaviour, so as to remove some of the uncertainty about why employees are productive.

There are three major factors affect labour productivity. These are the physical work environment; employee job performance; and product quality.

In this realization, various staff groups are making efforts such as industrial, process product and systems engineering to develop better automation, machines, tools, and work methods to enhance labour productivity. The belief is their increasing productivity through technology development is at least as important as employee job performance in increasing productivity.

The productivity of all factors of production can also be directly increased through reduction in defects, scrap, and re-work. You need to realize that employee job performance is a complex topic because no two people are exactly the same. Hence, their abilities, personalities, interests, ambitions, energy levels, education, training, and experience are bound to vary considerably.

Operations managers often consider these factors since blanket or common approaches to improving job performances may not be effective for all and sundry.

It is in recognition of these differences that efforts are being made by personnel, departments to select employees who have the desired abilities to develop training programmes for the improvement of employee skills.

There is growing importance of employee training and education.

Motivation is a complex variable in the equation of productivity.

One of the widely referred-to theories of motivation is the "hierarchy of needs" theory developed by Abraham Maslow. He saw human needs in the form of a hierarchy, starting in an ascending order from the lowest to the highest needs, and concludes that when one set of needs was satisfied, this kind of need ceased to be a motivator. In this sense, therefore, only unsatisfied needs are motivators, or cause people to act.

The basic human needs identified by Maslow in an ascending order of importance are the following:

1. *Physiological needs*

These are the basic needs for sustaining human life itself - food, water, clothing, shelter, sleep, and sexual satisfaction. Maslow took the position that until these needs are satisfied to the degree necessary to maintain life, other needs will not motivate people.

2. *Security or Safety needs*

These are the needs to be free from physical danger, and the fear or loss of a job property, food, clothing or shelter.

3. *Affiliation or Acceptance needs*

Since people are social beings, they need to belong and to be accepted by others. In other words, this means sense of belonging and love.

4. *Esteem needs*

According to Maslow, once people begin to satisfy their need to belong, they tend to want to be held in esteem both by themselves, and by others. This kind of need produces such satisfactions as power, prestige, status, and self-confidence.

5. *Self-Actualization needs*

Maslow regards this as the highest need in his hierarchy. It is the desire to become what one is capable of becoming, i.e. to maximize one's potential and to accomplish something.

If productivity is seen by employees as a means of satisfying their needs, high productivity is likely to result. Once employees have their needs satisfied through rewards that have been conditional upon productivity, the process is likely to be repeated.

Labour unions and work groups can influence employees to be either productive or unproductive. For instance, if employees think that their work groups may treat them as outcasts because they have been productive, they may not cooperate with management in this productivity-reward-productivity cycle.

This is the reason why operations managers should recognize the influence that work groups have on labour productivity. They therefore need to develop cooperative work groups. They also need to influence group norms through effective cooperation and communication.

**How Productivity can be Improved**

l. Develop productivity measures for all operations. This is based on the premise that measurement is the first step in managing and controlling an operation.

2. Look at the system as a whole in deciding which operations are most critical.

Productivity improvements to any non-bottleneck operation will not affect the productivity of the system. However, improvement in the bottleneck operation will lead to increases productivity, up to the point where the output rate of the bottleneck equals the output of the operations feeding it.

3. Develop methods achieving productivity improvements, such as soliciting ideas from workers (e.g. organizing teams of workers, engineers, and managers) studying how similar firms have increased productivity, and re-examining the way work is done.

4. Estimate reasonable goods for improvement

5. Make it clear that management supports and encourages productivity improvement. It is also important to consider incentive to reward workers for contributions.

6. Measure improvement and publicize them.

7. Don't confuse productivity with efficiency. This is because efficiency is a narrower concept that pertains to getting the best out of a given set of resources. Productivity, on the other hand, is a broader concept that pertains to effective use of overall resources.

**Chapter 16 - Work Methods**

It is usual for job design to begin with a methods analysis of an overall operation. It then moves from general to specific details of the job by concentrating on arrangement of the workplace and movements of the worker.

The need for methods analysis can come from a number of different sources, such as:

(a) Changes in tools and equipment

(b) Changes in product design, or new products

(c) Changes in materials or procedures

(d) Government regulations or contractual agreements

(e) Other factors (e.g. accidents, quality problems)

The main objective of improving work methods is to increase productivity by increasing the production capacity of an operation or group of operations, reducing the cost of the operations, or improving product quality.

**Steps involved in work analysis**

Works analysis can be done both for existing jobs and jobs that have not yet been performed. It might seem strange to you that we are talking about analyzing methods of non-existing jobs! Yet, it is important to establish a method for a new job, instead of allowing the job to start and then try to improve it later.

For an existing job, the procedure usually is to have the analyst observe the job as it is currently being performed, and then device improvements. For a new job however, the analyst must rely on a job description and an ability to visualize the operation in advance.

i. Make an initial investigation of the operation under consideration

ii. Decide what level of analysis is appropriate

iii. Talk with workers, supervisors, and others who are familiar with the operation. Get their suggestions for better ways to do the work.

iv. Study the present method. Use process Charts, time study, and other appropriate techniques of analysis. Thoroughly describe and evaluate the present method

v. Apply the questioning attitude, the principles of motion economy, and the suggestions of others. Device a new proposed method by using process charts and other appropriate techniques of analysis.

vi. Use time study, if necessary. Compare new and proposed methods. Obtain supervisors' approval to proceed.

vii. Modify the proposed method as required after reviewing the details with workers and supervisors.

viii. Train one or more workers to perform the proposed method on a trial basis. Evaluate the proposed method. Modify the method as required.

ix. Train workers and install the proposed method.

x. Check periodically to ensure that the expected savings are being realized.

In performing work methods analysis, certain diagrams and charts can be useful. These include flow-process charts and worker-machine charts.

**Flow Process chart**

Flow diagrams and process charts are about the most versatile techniques available for analyzing work methods. They are usually used together to eliminate or reduce delays, eliminate or combine tasks, or reduce travel time or distance.

**Worker-machine Chart**

A worker-machine chart is helpful in visualizing the portions of a work cycle during which an operator and equipment are busy or idle. The analyst can easily see when the operator and machine are working independently, and when their work overlaps or is interdependent. One area in which this type of chart is useful is in determining how many machines or how much equipment the operator can manage.

**Motion Study**

Motion study is the systematic study of human motions used during the performance of an operation. The purpose is to eliminate unnecessary motions and to identify the best sequence of motions for maximum efficiency. In this regard therefore, motion study can be an important avenue for productivity improvements.

The present practice of motion study can be traced to the work of Frank Gilbreth, who originated the concept in the bricklaying trade in the early 20th century.

There are a number of different techniques that motion study analysts can use to develop efficient procedures. We will only review motion study principles and micromotion study here.

**Motion study principles**

Gilbreth's work laid the foundation for the development of motion study principles, which are guidelines for designing motion-efficient work procedures. The guidelines are divided into three categories: principles for use of the body, principles for arrangement of the workplace and principles for the design of tools and equipment.

**Micromotion Study**

Frank Gilbreth and his wife, Lilian (an industrial psychologist) were also responsible for introducing motion pictures for studying motions, called micromotion study.

Apart from its direct application in the industry, micromotion study is now useful in other human endeavours such as sports and health care. The use of video camera and slow-motion replays enable analysts to study motions that would otherwise be too rapid to see. Today, it is a most important tool in sports administration, coaching, and arbitration in disputed competitions. It is also increasingly being used to analyze crimes. One other important advantage of micromotion study is that the resulting films provide a permanent record that can be referred to, not only for training workers and analysts, but also for settling job disputes involving work methods.

**Chapter 17 - Work Measurement**

Work measurement is the process of creating labour standards based on the judgment of skilled observers. Actually, job times are vital inputs for manpower planning, estimating labour costs, scheduling, budgeting and designing incentive systems.

**Relevance of Work Measurement**

Work measurement refers to the process of estimating the amount of worker time required to generate one unit of output. Its ultimate goal is usually to develop labour standards that will be used for planning and controlling operations, thereby achieving labour productivity.

Job times are important inputs for manpower planning, estimating labour costs, scheduling, budgeting, and designing incentive systems. In addition, from the workers' standpoint time standards provide an indication of expected output.

Time standard reflects the amount of time it should take an average worker to do a given job, working under typical conditions. The standards include expected activity time plus allowances for probable delays. Whenever a time standard is developed for a job, it is essential to provide a complete description of the parameters of the job because the actual time to do the job is sensitive to given methods, tools and equipment, raw materials inputs and workplace arrangement. For instance, changes in product design or changes in job performance brought about by a methods study should necessitate a new time study to update the standard time.

**Standard Time as Management Tool**

Managers use Standard Time in the following ways:

1. Establishing Prices and Costs: Managers can use labour and machine time standards to develop costs for current and new products, create budgets, determine prices and arrive at make or - buy decisions.

2. Motivating Workers: Standards can be used to define a day's work or to motivate workers to improve their performance. For example, under an inventive compensation plan, workers can earn a bonus for output that exceeds the standard.

3. Comparing alternative process designs: Time standards can also be used to compare different routings for an item and to motivate new work methods and new equipment.

4. Scheduling: Managers need time standards to assign task to workers and machines in ways that effectively utilize resources.

5. Capacity Planning: Managers can use time standards to determine current and projected capacity requirements for given demand requirements. Work-force staffing decisions also, may require time estimates.

6. Performance Appraisal: A worker's output can be compared to the standard output over a period of time in order to evaluate worker performance and productivity. A manager's performance can similarly be measured by comparing actual costs to standard costs of a process.

**Methods of Work Measurement**

- The time study method

- The elemental standard data approach

- The predetermined data approach and

- The work sampling method.

The particular method chosen usually depends on the purpose of the data.

**Chapter 18 - Learning Curves**

**A Soft Background to Learning and the Experience Curve**

When anybody starts something new, there is a form of learning process before one arrives at one's optimum ability.

Another fact we should note is that some activities are harder to learn than others, while some individuals are quicker to learn than others.

The point being made is that human performance of activities typically shows improvement when the activities are done on a repetitive basis. That is, the time required to perform a task decreases with increasing repetitions. Learning curves seem to summarize this phenomenon.

However, the degree of improvement and the number of tasks needed to realize the major portion of the improvement is a function of the task being done. For instance, if the task is short and somewhat routine, only a modest amount of improvement is likely to occur, and it generally occurs during the first few repetitions. If the task is fairly complex and has a longer duration, improvements will occur over a longer interval (i.e. larger number of repetitions). Hence learning factors have little relevance for planning or scheduling routine activities, but they do have relevance for complex repetitive activities.

**The Learning Curve**

The experience, or learning curve, sometimes called the manufacturing progress function, is a mathematical relationship between the cumulative production output and its cost, expressed either in financial terms or in production.

**Mathematical Representation of Learning Curve**

A mathematical learning curve can be developed by plotting production labour hours against the quantity of products produced. You will observe that the curve decreases exponentially, showing that when a new production starts, as the number of units produced increases, the labour-hours per unit decreases as operators become more familiar with the task.

The mathematical relationship has the exponential form:

Where

Tn = labour-hours/unit when n units are manufactured

T1 = labour-hours to produce the first unit

n = the unit number produced

b = a constant representing the slope of the curve

There are 3 approaches to learning curve problems;

1) Arithmethic analysis

2) Logarithmic analysis

3) Learning curve tables

In Logarithmic analysis;

b = slope or me learning curve

r = learning rate percentage

**Uses and Applications of Learning Curves**

We now know that as production personnel gain experience with a new product/service or operation, the labour-hours per unit fall. Consequently, labour standards are expected to decline on many products and operations, and cost standards, budgets, production, scheduling, staffing plans, and prices are necessarily affected.

In job shops and custom service operations, the learning-curve theory has been found to be important due to the following factors:

(a) Products and services tend to be custom designs that require workers to start near the beginning of small batches

(b) Batches tend to be small; thus labour-hours per unit improves dramatically from the first to the last unit

(c) Product/service designs tend to be complex; thus labour -hours per unit improve quickly. You should note that the application of learning curves to mass production and standard service operations is less significant because entirely new products or services are rare, and long production runs and simplified tasks combine to cause labour-hours per unit to improve only slightly.

Staff specialists have been found to routinely use learning-curve theory to develop labour cost for new products and services. This use allows companies to prepare cost estimates and product prices for bidding purposes.

The learning-curve approach has certain limitations:

1. It may be impossible either to develop precise labour-hour estimates for the first unit, or to determine the appropriate learning rate. Large unique projects often exhibit both at these difficulties.

2. Different workers have different learning rates. In a pure sense therefore, learning theory applies only to individual workers, but little difficulty is encountered in applying learning curves to groups of workers by applying an average learning rate.

3. Few products are completely unique. Workers usually will trained in the completion of tasks within their skill classifications. Past performance on related tasks therefore results in latent learning that is transferred to new products and services.

**Chapter 19 - Total Quality Management (TQM)**

The challenge for business today is to produce quality products or services efficiently. A company that meets this challenge can use quality as a competitive weapon.

Total quality management (TQM) stresses three principles: customer satisfaction, employee involvement, and continuous improvements in quality.

TQM also involves benchmarking, product and services design, process design, purchasing, and problem-solving.

For most companies, superior product quality is at the core of their business strategy. For these companies, attaining near-perfect product quality is seen as the principal means of capturing market share in global competition. The prominence of product quality in business strategy for many firms has come from the painful knowledge that one may lose business to lower-priced products, but one wins it back with superior product quality. Achieving superior product quality within a business requires a long-term process of changing the fundamental culture of the organization.

**Quality: A Management Philosophy**

Starting in the 1970s, Japanese manufacturers, with the help of American consultants such as W. Edwards Deming and Joseph M. Juran, began making quality a competitive priority.

Deming's philosophy was that quality is the responsibility of management, not the workers, and the management must foster an environment for detecting and solving quality problems.

Juran believed that continuous improvement, hands-on management, and training are fundamental to achieving excellence in quality.

Foreign competitors with superior goods may dominate the local market with inferior alternatives. A good example is the imported and local rice in Nigeria. Manufacturers need to listen to the customers or lose market share. This realization has helped the Japanese manufacturers over the years. The global economy of the 1990s and beyond dictates that companies provide the customer with an ever widening array of products and services having high level of quality.

**Customer-Driven Definition of Quality**

Customers define quality in various ways. Generally, quality may be defined as meeting or exceeding the expectations of the customer. However, quality has multiple dimensions in the mind of the consumer, and one or more of the following definitions may apply at any one time.

(a) *Conformance to specifications*

Customers expect the products or services they buy to meet or exceed certain advertised levels of performance.

(b) *Value*

Another way customers define quality is through value, or how well the product or service, serves its intended purpose at a price customers are willing to pay. How much value a product or service has in the mind of the customers depends on the customer's expectations before purchasing it.

(c) *Fitness for use*

In assessing fitness for use, or how well the product or service perform its intended purpose, the customer may consider the mechanical features of a product or the convenience of a service. Other aspects of fitness for use include appearance, style, durability, reliability, craftsmanship and serviceability.

(d) *Support*

Often the product or service support provided by the company is as important to customers as the quality of the product or service itself. Customers get upset with a company if financial statements are incorrect, responses to warranty claims are delayed, or advertising is misleading. Good product support can reduce the consequences of quality failures in other areas.

(e) *Psychological Impression*

People often evaluate the quality of a product or service on the basis of psychological impressions: atmosphere, image, or aesthetics. The appearance and actions of the service provider are very important. Nicely dressed, courteous, friendly, and sympathetic employees can affect the customer's perception of service quality

*Quality as a Competitive Weapon*

Attaining quality in all areas of a business is a difficult task because perceptions of quality by customers change over time.

A business's success depends on the accuracy of its prediction of consumer’s expectation and the ability to bridge the gap between those expectations and operating capabilities. Consumers are now quality-minded than in the past. Research findings indicate that a high quality product has a better chance of gaining market share than does a low-quality product.

Most modern firms believe that their total quality management (TQM) programmes are highly successful in retaining customers and building satisfaction.

Moreover, perception of a product as being of high quality by customers gives it better chance over those considered to be of low-quality even if the level of their quality is the same.

Good quality can pay off in higher profit. High-quality products and services can be priced higher than comparable lower quality ones and yield a greater return for the same sales naira. Poor quality erodes the firm's ability to compete in the market place and increase the costs of producing its products or service.

**Employee involvement**

One important component of TQM is employee involvement. A complete programme in employee involvement includes changing organizational culture, fostering individual development through training, establishing awards and incentives, and encouraging team work.

**Continuous Improvement**

Continuous improvement, based on a Japanese concept called "Kaizen", is the philosophy of continually seeking way to improve operations. It is also applicable to process improvement.

Continuous improvement involves identifying benchmarks of excellent practice and instilling a sense of employee ownership in the process.

Continuous improvement can also focus on problems with customers or suppliers. The bases of continuous improvement is that if people involved in a process can identify the needed changes to be made, the process can be improved upon. An organization should not wait until massive problem occurs before acting.

Start Continuous Improvement by Instilling the philosophy of continuous improvement involves the following processes:

(a) Train employees in the methods of statistical process control (SPC) and other tools for improving quality and performance.

(b) Make SPC methods a normal aspect of daily operations.

(c) Build work teams and employee involvement

(d) Utilize problem-solving tools within the work teams.

(e) Develop a sense of operator ownership in the process.

Note that employee involvement is central to the philosophy of continuous improvement. The last two steps are crucial if the philosophy is to become part of everyday operations. Problem solving addresses the aspects of operations that need improvement. A sense of operator ownership emerges when employees feel as though they own the processes and methods they use and take pride in the quality of the product or service they produce.

**Problem-solving process**

Firms that are actively involved in continuous improvement train their work teams to use the plan-do-check-act cycle of problem solving. The approach is called Deming wheel and it lies in the heart of the continuous improvement philosophy. The steps involved are;

1. Plan. The team selects a process (activity, method, machine, policy etc.) that needs improvement. The team then documents the selected process, by analyzing data; sets qualitative goals for improvement; and discusses various ways to achieve the goal. After assessing the benefits and costs of the alternatives, the team develops a plan with quantifiable measures for improvement.

2. Do. The team implements the plan and monitors progress. Data are collected continuously to measure the improvements in the process. Any further revisions are made as needed.

3. Check. The team analyzes the data collected during the do step to find out how closely the results correspond to the goals set in the plan step. If major short comings exist, the team may have to reevaluate the plan or stop the plan or stop the project.

4. Act. If the results are successful, the team documents the revised process so that it becomes the standard procedure for all who may use it. The team may then instruct other employees in the use of the revised process.

**The Cost of Poor Quality**

Defective and unsatisfactory product may cost a company up to 20 to 30 percent of its gross sales.

Four major categories of cost are associated with quality management: prevention, appraisal, internal failure, and external failure.

**Improving Quality through TQM**

Employee involvement and continuous improvement generally improve quality. But, TQM often focuses on benchmarking, product and service design, process design and purchasing.

*Benchmarking*

Benchmarking is a continuous systematic procedure that measures a firm's products, services and processes against those of industry leaders. Companies use the outstanding company in the industry as standard they would like to attain to. Typical measures used in, benchmarking include cost per unit, service per customer, processing time per unit, customer retention rates, revenue per unit, return on investment, and customer satisfaction levels. Benchmarking consists of four basic steps;

1. Planning - Identifying the product, service or process to be benchmarked and the firms (s) to be used for comparison, determine the measures of performance for analysis, and collect data.

2. Analysis - Determine the difference between the firm's current performance and that of the benchmark firm (s) and identify the causes of significant gaps.

3. Integration - Establishing goals and obtaining the support of managers who must provide the resources for achieving the goals.

4. Action - This involves determining the team affected by the changes, developing action plans and assignments, implementing the plan, monitoring progress and watching the level attained on the benchmark.

Benchmarking focuses on setting of quantitative goals for continuous improvement. Comparative benchmarking is based on comparisons with a direct industry competitor.

Functional benchmarking compares areas such as administration, customer service and sales operations with those of outstanding firms in an industry. Internal benchmarking involves using an organizational unit with superior performance as the benchmark for other units. All forms of

benchmarking are applied when there is a need for continuous improvement.

*Product and Service Design*

Because design changes often require changes in methods, materials, or specifications, they can increase defect rates. Change increases the risk of making mistakes, so stable product and service designs can help reduce internal quality problems. Stable designs may not be possible when a product or service is sold in markets globally.

Although changed designs have the potential to increase market share, management must be aware of possible quality problems resulting from changes. A firm may need to change design to remain competitive; it should carefully test new designs and redesign the product with a focus on the market. Higher quality and increased competitiveness are exchanged for added time and cost.

Another dimension of quality related to product design is reliability. Reliability is the probability that the product will be functional when used. Products often consist of a number of components that must be operative for them to perform as expected. Some products can be designed with extra components/subsystems so that if one system component fails another can be activated.

Suppose that a product has subsystems, each with its own reliability measure. The reliability of the product is equal to the product of the reliabilities of all the subsystems.

*Process Design*

Process designs greatly affect product quality.

The purchase of new and efficient machinery can help to prevent or overcome quality problem. The cost of the machinery is the trade-off for reducing the percentage of defects and their cost.

One of the keys to obtaining high quality is concurrent engineering in which operation's manager work hand in hand with designers in the initial phases of product or service design to ensure that production requirements and process capabilities are synchronized. This results in better quality and shorter development time.

Quality Function Deployment

A key to improving quality is to link the design of products or services to the processes that produce them. Quality Function Deployment (QFD) is a means of translating customer requirements into the appropriate technical requirements for each stage of product or service development and production.

This approach seeks answers to the following questions;

(a) Voice of the customer - what do our customers need and want?

(b) Competitive analysis - How well are we doing relative to our competitors, in terms of our customers?

(c) Voice of the engineer - what technical measures relate to our customers' needs?

(d) Correlation - what is the relationship between the Voice of customer and the voice of the engineer?

(e) Technical comparison - How does our product/service perform compared to that of our competitors?

(f) Trade-offs - what are the potential technical trade - offs?

The QFD approach provides a way to set targets and debate their effects on product quality. QFD encourages inter functional communication for the purpose of improving product quality.

*Purchasing Considerations*

Most firms depend on outside suppliers for some of the materials, services, or equipment used in producing their products and services. Large companies have many of such suppliers, some of which supply them the same material. The quality of these inputs can affect the quality of the firm's work Both the buyer's approach and specification management are keys to controlling supplier quality. The firm's buyer must emphasize the cost, and speed of delivery of the supplier as well as the quality of the product. The buyer identifies suppliers with high - quality products and arranges to buy from them.

The specifications for the purchased items must be clear and realistic. The buyers initiate process capability studies for important products. This involves trial runs of small product samples to ensure that the quality is as specified and will perform as desired at the given cost. Management needs to allow sufficient time for the purchasing unit and may work closely with other units e.g. engineering to ensure quality control.

**Tools for Improving Quality and Performance**

The first step in improving quality of an operation is data collection. There are seven tools for organizing and presenting data to identify areas for quality and performance improvement. These are:

- Checklists

- Histograms ad Bar charts

- Pareto Charts

- Scatter diagrams

- Cause and effect diagrams

- Graphs

**Data Snooping**

Each of the tools for improving quality may be used independently, but their power is greatest when they are used together. Managers may need to shift data to clarify the issues involved in deducing the causes. This process is called data snooping.

**National Quality Standards**

Products and services quality are standardized by various public and private agents in Nigeria. These could be trade unions, professional bodies or government agencies e.g. licensing office. Accountants, Engineers etc. have their professional bodies that maintain standard in their profession. The Nigerian University Commission for instance, maintains standard and quality of university education in Nigeria. The National Agency for Food and Drug Administration and Control (NAFDAC) is saddled with responsibility of maintaining standard in food and pharmaceutical industry.

**International Quality Standard**

Companies selling in international markets may have difficulty complying with varying quality documentation standards in countries where they do business.

To cope with this problem, the international organization for standardization devised a set of standards called ISO 9000 for companies doing business in the European Union. Also, a new set of standards, ISO14000, were devised for environmental management systems.

(a) The ISO 9000 standards is a set of standards governing documentation of a quality programme. Companies become certified buy proving to a qualified external examiner that they have complied with all the requirements. Companies thus certified are listed in the directory for

potential customer to know that such companies can own-up their claims on their products. This tells nothing on the actual quality of the product.

The ISO 9000 consists of 5 documents: ISO 9000 - 9004

(b) ISO 14000 - An Environmental management system.

The ISO 14000 standards require participating companies to keep track of their raw materials use and their generation, treatment, and disposal of hazardous wastes. The standard is to ensure improvement in environmental performance. ISO 14000 is a series of 5 standards covering the following areas;

- Environmental management system

- Environmental performance evaluation

- Environmental labeling

- Life-cycle assessments

**Chapter 20 - Maintenance and Reliability**

Maintaining the production capability of an organization is an important function in any production system.

It is through this that production equipment are adjusted, repaired and kept in good operating conditions.

The reasons for keeping equipment and facilities in perfect operating condition are not only to

avoid interruption to production, but also to keep production cost low, keep product quantity high, maintain safe working conditions, and avoid late on late shipments to customers.

When equipments malfunction in both manufacturing and service industries, the consequences have a direct impact on:

(i) *Production capacity:* Naturally, equipment sidelined by breakdown cannot produce. This way, the capacity of the system is reduced.

(ii) *Production costs:* Since machines are not functioning, workers too would be made idle. This situation cause labour costs per unit to increase. Apart from this, when machine malfunction causes scrap products to be produced, unit labour and material costs increase.

Furthermore, maintenance department budgets include such costs as the costs of providing repair facilities, repair crew, preventive maintenance inspections, standby machines, and spare parts.

(iii) *Product and service quality:* Usually, poorly maintained equipment produces low -quality products.

(iv) *Employee or customer safety:* Worn-out equipment is most likely to fail at any moment while in operation. These failures can cause injuries to workers, as well as to customers (especially in the services sector)

(v) *Customers satisfaction:* Whenever production equipment breaks down, the initial after math is that products cannot be produced according to the master production schedules. In essence, customers may not receive products when promised.

For better management, there is always a maintenance department headed by a maintenance manager who reports to the plant or manufacturing manager depending on the organization.

Maintenance activities are often organized into 2 categories;

1) Buildings and Grounds

2) Equipment maintenance

**Approaches to maintenance**

1) Reactive approach(Breakdown maintenance)

2) Proactive approach (Preventive maintenance)

The best approach is to seek a balance between preventive and breakdown maintenance that will minimize their combined cost.

**Preventive Maintenance (PM)**

The goal of PM is to reduce the incidence of breakdown in a plant/equipment in order to avoid the associated cost.

These can include loss of output, idle workers, schedule reduction; damage to other equipment, products, or facilities, and repairs, which may involve maintaining inventories of spare parts, repair tools and equipment, and repair specialists.

PM can be an important factor in achieving operations strategy.PM is periodic and can be programmed to the availability of maintenance personnel as well as to avoid interference with operating schedules.

PM is programmed using 3 options;

(i) The result of planned inspections that reveal a need for maintenance

(ii) According to the calendar (passage of time)

(iii) After a pre-determined number of operating hours.

PM is performed just prior to a breakdown or failure because this will result in the longest possible use of equipment of facilities without a breakdown.

Predictive maintenance is an attempt to determine when to perform PM activities. It is based on historical records and analysis of technical data to predict when an equipment is about to fail.

A good PM effort relies on complete records for each piece of equipment.

Total PM(TPM) was developed in Japan has the workers perform PM on the machines they operate rather than using a separate maintenance personnel for the task.

**Breakdown Maintenance (BM)**

Though the risk of breakdown can be drastically reduced by an effective PM program, occasional breakdowns can still occur.

Firms with good preventive practices have some need for breakdown programmes.

It is obvious that organizations that rely less on PM have an even greater need for

effective ways of dealing with breakdowns.

Very much unlike PM, breakdowns cannot be scheduled. Rather they must be dealt with on an irregular basis (i.e. as they occur). The following approaches are being used to deal with breakdowns:

(i) Standby or backup equipment that can be quickly pressed into service.

(ii) Inventories of spare parts that can be installed as needed, thereby avoiding lead times involved in ordering parts, and buffer inventories, so that other equipment will be less likely to be affected by short-term downtime of a particular piece of equipment.

(iii) Operators who are able to perform at least minor repairs on their equipment.

(iv) Repair people who are well trained and readily available to diagnose and correct problems with equipment.

The extent to which organizations pursues any or all of these approaches depends on how important a piece of equipment is to the overall production system.

At one extreme, the equipment is the focal point of the production system and the other extreme is that the equipment is rarely used.

BMs are very important when you take note of the degree of importance of the equipment to the production system as well as the ability of the system to cope without it for some time.

**Replacement Decisions**

These are situations when breakdowns become frequent and/or costly. The manager is thus faced with a trade-off decision in which costs are important consideration. What is the cost of replacement compared with the cost of continued maintenance? At times, a question like this is difficult to resolve, most especially if future breakdowns cannot be readily predicted. The manager may thus, need to examine historical records in order to project future experience.

Another important factor is technological change. For instance, newer equipment may have some features that favour replacement over either preventive or breakdown maintenance. At the same time, the removal of old equipment and the installation of new equipment may cause disruptions to the system, which may actually be greater than the disruptions caused by breakdowns. In addition, employees may have to be trained to operate the new equipment. Finally, forecasts of future demand for the use of the present or new equipment must be taken into account.

**Machine Reliability**

It is necessary for you to know the concepts of reliability and their relationship to maintenance management. Machine reliability is the likelihood of a machine breaking down, malfunctioning, or needing repairs in a given time period or number of hours of use. If machine reliability can be increased, the incidence of machine breakdowns and the cost of the havoc caused in production by breakdowns can also be reduced.

There are three approaches to improving machine reliability:

- over-design

- design simplification

- redundant components

All these take place by the time a machine is designed.

Over design means enhancing a design to avoid a particular type of failure. For instance, if a machine has only a few independent critical interacting parts, then over design may be an effective way of increasing machine reliability.

Design simplification implies a reduction in the number of interacting parts in a machine. Since there are now fever parts that can fail, machine reliability increases when the number of interacting part s is reduced.

Redundant components are the building of backup components right into the machine so that if one part fails, its backing is automatically substituted. These three approaches can be sued together or separately to design more reliable machines.

**Secondary Maintenance Responsibilities**

As earlier mentioned, all maintenance departments are responsible for the repair of buildings and equipment and for performing certain preventive maintenance inspections, repairs, lubrication, and adjustments.

Additionally, some particular responsibilities have traditionally been added to these departments. For instance, housekeeping, janitorial, window cleaning, ground keeping and painting services are now usually performed by maintenance departments.

These activities often embrace all areas of the facility, from restrooms to offices to production departments to warehouses. Within some plants, it is usual to find the area around each production worker's immediate workplace being cleaned by the worker, while the appearance and cleanliness of all other areas are the responsibility of the maintenance department.

Again, in some organizations, additional activities such as new construction, remodeling, safety equipment maintenance, loss prevention, security, public hazard control. Waste disposal and recycling and pollution control responsibilities have been assigned to their maintenance departments.

**Current Trends in Maintenance Management**

Modern Production machinery is far more complex than it was years ago. Newer technology and other developments have resulted in the way complex machines are maintained. Based on these development, we see the following;

- Special training programs

- Maintenance outsourcing

- Technology has reduced the cost of maintenance while improving the performance of production machines

- Another modern trend is the application of computers to maintenance

 management. There are at least five general areas in maintenance that

 commonly use computer assistance. These are:

 (i) Scheduling maintenance projects

 (ii) Maintenance cost reports by production department, cost category and other classifications

 (iii) Inventory status reports for maintenance parts and supplies

 (iv) Parts failure data

 (v) Operations analysis studies, which may include computer simulation, waiting lines (queuing theory), and other analytical programmes