

CPSP

**CERTIFIED PROCUREMENT AND SUPPLY
PROFESSIONAL OF KENYA**

PART III

OPERATIONS MANAGEMENT

STUDY TEXT

PL3.05 OPERATIONS MANAGEMENT

PL3.05.1 Introduction

This module is intended to equip the trainee with knowledge, skills and attitudes in operations management, in order to build the trainees capacity to plan, control, analyze and improve organizational processes.

PL3.05.2 General Objectives

At the end of the module, the trainee should be able to:

- a) Explain the concept of Operations Management
- b) Apply operational planning and control techniques in supply chain management
- c) Develop appropriate operations strategies
- d) Appreciate decision making techniques in operations management
- e) Apply resource planning skills in production management
- f) Explain the importance of facility location and layout in Operations Management
- g) Explain quality management principles used in Operations Management
- h) Analyze the sources of ideas and materials for product and services design
- i) Outline the need for the efficient maintenance of plant and equipment

PL3.5.1 Overview of operations management

Competence

The trainee should have the ability to apply operations management principles and objectives in the management of supply chain functions

Content

Theory

1. Definition of terms used in Operations Management
2. Historical evolution of operations management
3. Objectives and characteristics of Operations Management
4. Transformation process in operations Management
5. Product versus service operations
6. Frameworks for analyzing operations
 - i. Value Chain
 - ii. Systems Approach
7. Operation Management across different supply chains in the various sectors.

Practice

1. Application of knowledge of operations management in supply chain management

PL3.5.2 Value analysis in supply chain

Competence

The trainee should have the ability to manage value analysis in the supply chain function.

Content

Theory

1. Definition of terms used in value analysis
2. The need for value analysis in supply chain
3. Types of value analysis in supply chain
4. Value analysis tools and techniques in supply chain

Practice

1. Analysis of tools and techniques used in value analysis in supply chain.

PL3.5.3 Operations planning and control

Competence

The trainee should have the ability to apply operations planning and control techniques in supply chain management

Content

Theory

1. Definition of terms used in Operations Planning and Control
2. Benefits of Operations Planning and Control
3. Functions of Operations Planning
4. Capacity Planning and Control
 - i. Demand Forecasting
 - ii. Dependent and Independent demand
 - iii. Capacity planning and Process
 - iv. Inventory Planning and Control
5. Balancing Supply and Demand
 - i. Scheduling

- ii. Loading
- iii. Sequencing and
- iv. Expediting

Practice

- 1. Calculation of forecast for demand using the various qualitative and quantitative techniques
- 2. Preparation schedules using various scheduling techniques in different scenarios

PL3.5.4 Operations strategy

Competence

The trainee should have the ability to formulate operations strategies in supply chain management.

Content

Theory

- 1. Concept and framework of operations strategy
- 2. Roles of strategic thinking in operations management
- 3. Operations Management Strategy Development Process
- 4. Strategic Planning for Production and Operations
- 5. Performance objectives of Operations Management
- 6. Concept of Agility, Operational Trade-offs, Efficiency and Productivity
 - i. Agility
 - ii. Properties of Operational Trade-offs
 - iii. Operational Efficiency and Productivity

Practice

- 1. Formulation of Operations strategy in supply chain management

PL3.5.5 Operations decision-making

Competence

The trainee should have the ability to apply decision-making techniques in order to make operational decisions

Content

Theory

1. Characteristic of Operations Decisions
 - i. Management as a science
 - ii. Framework for Decision-Making
2. Decision Making Methodology
3. Decision Support System
4. Supply chain operations decision making techniques

Practice

1. Analyzing decisions in a given situation using different decision making techniques

PL3.5.6 Production management and resource planning

Competence

The trainee should have the ability to apply production planning elements in supply chain management

Content

Theory

1. Concept and objectives of Production management
2. Classification of Production System
3. Objectives and functions of Production Planning and Control
4. Process and Phases of Production Planning and Control
5. Resource and requirements planning
 - i) Material Requirements Planning (MRP)
 - ii) Manufacturing Resource Planning (MRP II)
6. Capacity Planning, management and Routing
7. Operations Planning and Scheduling principles and Systems
8. Enterprise Resource Planning (ERP)
9. Lean production management
 - i. The basic elements of Lean Production
 - ii. JIT
 - iii. Flexible Resources
 - iv. The Pull System
 - v. Kanbans
 - vi. Small Lots
 - vii. Quick Setups

Practice

1. Application of production planning elements in supply chain management

PL3.5.7 Systems design

Competence

The trainee should have the ability to apply the various design systems in operating environment.

Content

Theory

1. Manufacturing and Service Systems
2. Design and Systems Capacity
3. Production systems
 - i. Types of production systems
 - ii. Factors that influence the choice of production systems
4. Operations Management design systems
 - i. Customer Relationship Management (CRM)
 - ii. Product Life cycle Management (PLM)
 - iii. Supplier Relationship Management (SRM)

Practice

1. Identification of types of production systems
2. Application of the various design systems in operating environment

PL3.5.8 Facility location and layout

Competence

The trainee should have the ability to explain the importance of facility location and layout in operations management

Content

Theory

1. Definition of terms used in Facility Location and Layout
2. Factors that determine the location of operating units
3. Location analysis tools
4. Objectives and principles of Plant Layout
5. Classification and design of Plant Layout

Practice

1. Application of location methods in facility location decision making
2. Illustration of types of plant layout
3. Design an operating layout

PL3.5.9 Total Quality Management (TQM)

Competence

The trainee should have the ability to apply quality management principles in operations management

Content

Theory

1. Definition of terms used in Total Quality Management (TQM)
2. The Evolution of Quality Management
3. Importance and benefits of high quality
4. Quality Circles
5. Costs of Quality
6. Concepts of Total Quality Management and Continuous Improvement
7. Quality Control Tools/ Statistical Process Control
8. ISO 9000 and ISO14000 series
9. Six Sigma
10. Quality Assurance

Practice

1. Application of quality control tools in supply chain management

PL3.5.10 Benchmarking in operations management

Competence

The trainee should have the ability to effectively carry out a benchmarking exercise in Operations Management

Content

Theory

1. Meaning of Benchmarking
2. Purpose for Benchmarking in Operations Management
3. Types of Benchmarking in Operations Management

Practice

1. Discussion of the types of Benchmarking in Operations Management

PL3.5.11 Product and service design

Competence

The trainee should have the ability to identify sources of ideas and materials for product and services design

Content

Theory

1. Principles of product and service process design
2. Sources of new product and service design
3. The product and service design process
4. Design for products and service with respect to logistics and quality of supply
5. Product and service analysis
 - i. Value engineering
 - ii. value analysis
6. Contribution of Supply Chain Management in Product and Service design

Practice

1. Illustration of the process of product and design

PL3.5.12 Maintenance management

Competence

The trainee should have the ability to prepare a plant and equipment maintenance schedule.

Content

Theory

1. Definition of terms used in Maintenance Management
2. Importance of Maintenance Management
3. Maintenance Planning and scheduling
4. Modern Scientific Maintenance Methods
5. Achieving minimum breakdown through maintenance Management
 - i. Total Productive Maintenance (TPM)
 - ii. Pillars of TPM
 - iii. Similarities and Differences between TQM and TPM
6. Waste management

- i. Reasons for generation and accumulation of obsolete, surplus and scrap items
- ii. Identification and control of waste
- iii. Disposal of Scrap

Practice

1. Preparation of a plant and equipment maintenance schedule

PL3.5.13 Emerging trends and issues in operations management

Competence

The trainee should have the ability to identify various emerging issues in operations management

Content

Theory

1. Emerging trends and issues in Operations Management.
2. Challenges and opportunities posed by the emerging trends and issues in Operations Management
3. Approaches of coping with opportunities and managing challenges posed by the emerging issues and trends in Operations Management

Practice

1. Dealing with challenges and opportunities posed by issues and trends in Operations Management.

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TOPIC 1

OVERVIEW OF OPERATIONS MANAGEMENT

DEFINITION OF TERMS USED IN OPERATIONS MANAGEMENT

Operation it is defined in terms of the mission it serves for the organisation, technology it employs and the human and managerial processes it involves. Operations in an organisation can be categorised into Manufacturing Operations and Service Operations.

Manufacturing operation is a conversion process that includes manufacturing yields a tangible output: a product,

Service operation is, a conversion process that includes service yields an intangible output: a deed, a performance, an effort

Operating system is a configuration of resources combined for the provision of goods or services

Operations management is the process which combines and transforms various resources used in the production/operation subsystem of the organization into value added products/services in a controlled manner as per the policies of the organization.

Overview

The operations managers have the prime responsibility for processing inputs into outputs. They must bring together a production plan that effectively uses the materials, capacity and knowledge available in the production facility. Given a demand on the system work must be scheduled and controlled to produce goods and/or services required. Control must be exercised over such parameters such as costs, quality and inventory levels. The definition of the operations management contains following keywords: Resources, Systems, Transformation and Value addition activities.

- **Resources**

Resources are the human, material and capital inputs to the production process. Human resources are the key assets of an organisation. As the technology advances, a large proportion of human

input is in planning and controlling activities. By using the intellectual capabilities of people, managers can multiply the value of their employees into by many times. Material resources are the physical facilities and materials such as plant equipment, inventories and supplies. These are the major assets of an organisation. Capital in the form of stock, bonds, and/or taxes and contributions is a vital asset. Capital is a store of value, which is used to regulate the flow of the other resources.

- **Systems**

Systems are the arrangement of components designed to achieve objectives according to the plan. The business systems are subsystem of large social systems. In turn, it contains subsystem such as personnel, engineering, finance and operations, which will function for the good of the organisation. A systems approach to operations management recognises the hierarchical management responsibilities. If subsystems goals are pursued independently, it will results in sub-optimization. A consistent and integrative approach will lead to optimization of overall system goals. The system approach to specific problems requires that the problem first be identified and isolated from the maze of the less relevant data that constitute the environment. The problem is abstracted from the overall (macro) environment. Then it can be broken into manageable (micro) parts and analysed and solutions proposed. Doing this analysis is advantageous before making any changes. If the solution appears to solve the problem in a satisfactory way, changes can be made to the real system in an orderly and predictable way. The ability of any system to achieve its objective depends on its design and its control. System design is a predetermined arrangement of components. It establishes the relationships that must exist between inputs, transformation activities and outputs in order to achieve the system objectives. With the most structured design, there will be less planning and decision-making in the operations of the system. System control consists of all actions necessary to ensure that activities conform to preconceived plans or goals. It involves following four essential elements:

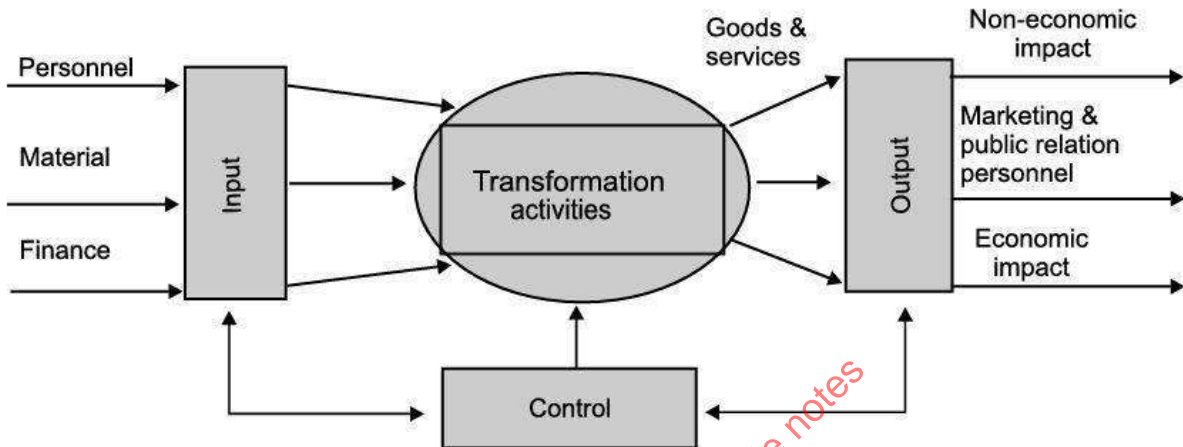
1. Measurement by an accurate sensory device.
2. Feedback of information in a timely manner.
3. Comparison with standards such as time and cost standards.
4. Corrective actions by someone with the authority and ability to correct.

A closed loop control system can automatically function on the basis of data from within its own system.

- **Transformation and Value Adding Activities**

The objective of combining resources under controlled conditions is to transform them into goods and services having a higher value than the original inputs. The transformation process

applied will be in the form of technology to the inputs. The effectiveness of the production factors in the transformation process is known as productivity. The productivity refers to the ratio between values of output per work hour to the cost of inputs. The firms overall ratio must be greater than 1, then we can say value is added to the product. Operations manager should concentrate improving the transformation efficiency and to increase the ratio.



Schematic model for operations/production system

Elements of operations management

The operations function can be connected to other functional operations within organization such as marketing, finance, human resource and etc. so it can be described that all functional areas undertake operations activities because they all produce the services and goods. Thus, today every company realized that operations management is important and also agreed that is the main core function to organize their organization. The key elements of Operations Management are;

- **Product selection and design:** The right kind of products and good designs of the products are crucial for the success of an organizing. Products/services, therefore, must be chosen after detailed evaluation of the product/services alternatives in conformity with the organization's objectives. Techniques like value engineering may be employed in creating alternate designs, which are free from unnecessary features and meet the intended functions at the lowest cost.
- **Process selection and planning:** Process selection decisions include decisions concerning choice of technology, equipment, machines, material handling systems, mechanization and automation. Process planning involves detailing of processes if resource conversion required and their sequence.

- **Facilities (Plant) location:** Plant location decisions are strategic decisions and once plant is set up at a location, it is comparatively immobile and can be shifted later only at a considerable cost and interruption of production. Although problem of location choice does not fall within preview the production function and it occurs infrequently, yet it is of crucial importance because of its major effect on the performance of every department including production. Therefore, it is important to choose the right location, which will minimize total 'delivered customer' cost (Production and distribution cost).
- **Facilities (Plant) layout and materials handling:** Plant layout is concerned with relative location of one department (Work center) with another in order to facilitate material flow and processing of a product in the most efficient manner through the shortest possible time. A good layout reduces material handling cost, eliminates delays and congestion, improves co-ordination, provide good housekeeping etc. while a poor layout results in congestion, waste, frustration, inefficiency and loss of profit.
- **Capacity Planning:** Capacity planning concerns determination and acquisition of productive resource to ensure that their availability matches the demand. Capacity decisions have a direct influence on performance of production system in respect of both resource productivity and customer service (i.e. delivery performance). Excess capacity results in low resource productivity while inadequate capacity leads to poor customer service. Capacity planning decisions can be short-term decisions. Long-term capacity planning decisions concern expansion/contraction of major facilities required in the conversion process, economics of multiple shift operation, development of vendors for major components etc. Short-term capacity planning decisions concern issues like overtime working, sub-contracting, shift adjustments etc. Break-even analysis is a valuable tool for capacity planning.
- **Production Planning and Control (PPC):** Production planning is the system for specifying the production procedure to obtain the desired output in a given time at optimum cost in conformance with specified standard of quality, and control is essential to ensure that manufacturing takes place in the manner stated in the plan.
- **Inventory control:** Inventory control deals with determination of optimal inventory levels of raw materials, components, parts, tools; finished goods, spares and supplies to ensure their availability with minimum capital lock up. Material requirement planning (MRP) and Just in time (JIT) are the latest techniques that can help the firm to reduce inventory.
- **Quality assurance and control:** Quality is an important aspect of production system and it must ensure that services and products produced by the company conform to the declared quality standards at the minimum cost. A total quality assurance system includes such

aspects as setting standards of quality, inspection of purchased and sub-contracted parts, control of quality during manufacture and inspection of finished product including performance testing etc.

- **Work-study and job design:** Work-study, also called time and motion study, is concerned with improvement of productivity in the existing jobs and the maximization of productivity in the design of new jobs. Two principal component of work-study are: Method study and Work measurement.
- **Maintenance and replacement:** Maintenance and replacement involve selection of optimal maintenance (preventive and/or breakdown) policy to ensure higher equipment availability at minimum maintenance and repair cost. Preventive maintenance, which includes preventive inspection, planned lubrication, periodic cleaning and upkeep, planned replacement of parts, condition monitoring of the equipment and machines, etc. is most appropriate for critical machines.
- **Cost reduction and cost control:** Effective production management must ensure minimum cost of production and in this context cost reduction and cost control acquires significant importance. There are large numbers of tools and techniques available that can help to make a heavy dent on the production cost.

Responsibilities of operations manager

Operations managers are essential to any large business organization. The core responsibilities of operations managers tend to be similar across many industries.

- **Policy Formulation**

Formulating policy is one of the core duties of an operations manager. Companies must operate and function on a daily basis within a prescribed set of guidelines. These guidelines are generally established by operations managers. These can include how different departments within the company or organization communicate and cooperate with one another. Policies can also include disciplinary actions taken when employees break company rules.

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TOPIC 2

VALUE ANALYSIS IN SUPPLY CHAIN

DEFINITION OF TERMS USED IN VALUE ANALYSIS

Value analysis can be defined as a systematic analysis and evaluation of techniques and functions in the various areas of a concern with a view to exploring channels of performance improvement so that the value attached to a particular product or service may be improved.

It endeavors to achieve the maximum possible value for a given cost by a continuous process of planned action and aims at cost reduction from the point of view of value.

Although initially the group of techniques, aimed at the systematic identification of unnecessary costs and exploring channels of performance improvement, was used mostly in the engineering field which gave it the name of value engineering, it is now used in the various areas of a concern such as marketing, purchasing, financing etc.

Keeping in view the wide applicability of this technique, value analysis is now used instead of value engineering.

Value analysis involves a creative approach for finding out unnecessary costs. Such costs are those costs which though incurred on a product or service, are unnecessary and do not improve its quality or efficiency, give it a better appearance, prolong its life, nor provide any additional satisfaction to the customer.

By eliminating these costs; the cost of the product or service can be reduced, and the sales and the resulting profit proportionately increased.

Value analysis is an effective tool for cost reduction. Cost reduction may be achieved by economizing expenditure and increasing productivity whereas value analysis probes into the economic attributes of value. In value analysis it is possible to improve performance, increase the value of a product and thus reduce costs by a continuous process of planned action.

Value analysis lays emphasis on searching out new ideas while cost reduction is usually confined to already known facts. Hence, value analysis is not a substitution for cost reduction methods but it is a completely different procedure for accomplishment of greater results leading to the elimination of unnecessary costs and value improvement of a product or service.

Value analysis is sometimes taken as value engineering. There is no doubt that value engineering is an important aspect of value analysis and is concerned with production technology, product designing, fabrication and quality control.

Broadly speaking value engineering is mainly concerned with production while value analysis goes up to the marketing stage for the systematic identification of unnecessary costs and efficiently eliminating them. The scope of value analysis thus is broad and extends to all operations of an organisation where cost is incurred.

Key points to note:

Value analysis is a systematic, formal and organised process of analysis and evaluation.

The analysis concerns, the function of a product to meet the demands or application needed by a customer.

Understanding the use of a product implies that specifications can be established to assess the level of fit between the product and the value derived by the customer.

To succeed, the formal management process must meet this functional specification and performance criteria, any attempt to improve the value of a product must consider two elements:

- The use of the product
- The value that comes from ownership

Factors in value analysis

The key focus of the value analysis approach is therefore the management of functionality to yield value for customers. If a company seeks to reduce the costs that are unnecessary or items of the product that provides no functional value to the customer.

The value analysis approach is therefore formal and systematic because it is directed towards highlighting and dealing with these recoverable costs of production. The objective is to create value for money as opposed to creating new products that don't provide customer satisfaction but are relatively inexpensive.

The rules governing the application of value analysis are therefore:

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TOPIC 3

OPERATIONS PLANNING AND CONTROL

Production is an organized activity of converting raw materials (RM) into useful products. Production activity takes place in a wide range of manufacturing and service sectors. Production system requires the optimal utilization of natural resources like men (labor), money, machine, materials, and time. Thus, it is essential that before starting the work of actual production, production planning is done in order to anticipate possible difficulties, and decide in advance as to how the production should be carried out in a best and economical way.

Operation and Production are sometimes used as synonyms but in reality operation is a more comprehensive term, whereas production is a special type of operation in industrial context.

Production, or Operations Planning and Control (OPC) is concerned with implementing the plans, i.e., the detailed scheduling of jobs, assigning of workloads to machines (and people), and the actual flow of work through the system. Operations Planning and Control (OPC) philosophy is: —First plan your work, then work your plan. Before starting any work, planning is necessary for the effective utilization of available resources. Planning is the determination phase of production management.

Operations' planning is concerned with the determination, acquisition and arrangement of all facilities necessary for the future operations.

Operations control is concerned with the implementation of a predetermined operations plan or policy and the control of all aspects of operations according to such a plan or policy. It is also called 'Production Planning and Control (PPC)' in manufacturing sector. Formally OPC or PPC can be defined as the process of planning the production in advance, setting the exact route of each item, fixing the starting and finishing date for each item, giving production orders to shop and lastly following up the progress of products according to orders. It is also called the 'nerve center' of the factory.

BENEFITS OF OPERATIONS PLANNING AND CONTROL

The benefits of a better OPC are summarized in three groups as follows:

1. Benefits to Consumers/Investors.

Better planning leads to increased productivity in the firm, efficient deliveries of the products at proper time, more products available to the consumers at cheaper price, and better quality. This means more values for the consumers' money and more satisfaction from the products. This also means lots of profit margin to the investors who in turn can recycle more money back to the production system, which will improve the efficiency and productivity of the plant, and thus the cycle may go on.

2 Benefits to Producers, Employees, Community and Share-holders.

Better planning means that the firm can earn more money and in turn can pay better wages to its employees. There will not be any interrupted employment as it was in older days, when there used to be none or very little scientific planning. This will lead to job security, improved working conditions and thus increased satisfaction among the employees. This will also keep the employees highly motivated for more productive work. To the investors or the share-holders there is a security of money and an adequate return in the form of dividends. The Government may get lots of revenue by way of taxes and the community may get more economic and social stability, better infrastructure.

3. Benefits to the Nation.

The Nation gains economic, political and social stability, a better image on the global front, and increased say in the global policy. It also brings security and prosperity to the nation.

FUNCTIONS OF OPERATIONS PLANNING

The following are the key functions of Operations Planning and Control:

- a) Release orders to the system in accordance with the priority plan. Priority means control over the status of jobs and work activities by specifying the order in which materials or jobs are assigned to work centers.
- b) Assign jobs to specific work centers (including machine loading, or shop loading). These activities are also called *'short-run capacity planning'*.
- c) Provide sequencing priorities to specify the order in which jobs are to be processed. This function may also include the dispatching function, which is the actual authorization for the work to begin.
- d) Control the manufacturing lead time by tracking and expediting jobs if required.
- e) Monitor the priority status of jobs via summary, scrap, rework, and other reports.
- f) Monitor the capacity status of facilities via input/output reports of workload versus capacity. The input/output controls are also referred to as *'short-run capacity control'*.

Specific activities in operations planning and control

- Forecast the demand for an existing product and find out the demand of a new product. Also estimate in advance the cost of a new product.
- Plan for capacity required to meet production needs. Ensure utilization of capacity, equipment and other facilities.
- Schedule production activities with respect to the resources like labor, machines, working hours, etc. Fix the starting and finishing dates for each item.
- Plan for materials (to be available in right time and in right quantity). Maintain appropriate inventories in the correct location.
- Prepare route sheet, and schedules for production and machine loading.
- Issue orders for various activities to be performed.
- Simplify the activities and standardize the methods.
- Track materials, labor, machines, customer orders and other resources. Direct and coordinate the company's resources towards the achievement of desired goals in the most efficient manner.

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TOPIC 4

OPERATIONS STRATEGY

CONCEPT AND FRAMEWORK OF OPERATIONS STRATEGY

CONCEPT OF OPERATIONS STRATEGY

Operations management includes all the activities that are required to create or deliver a product or service. Operations engage the majority of the people employed and assets deployed in most organisations. Thus the way operations is managed in the long-term, the operations strategy, is

likely to be a vital element of an organisation's success. Two generic approaches to operations strategy are the market-based and resource-based approaches.

Using a market-based approach an organisation makes a decision regarding the markets and the customers within those markets that it intends to target. Along with meeting customer needs within a market the position the organisation takes in that market will in part depend on the actions of its competitors. Thus the organisation's market position is one in which its performance enables it to attract customers to its products or services in a more successful manner than its competitors.

A resource-based view of operations strategy works from the inside-out of a firm, rather than the outside-in perspective of the market-based approach. Here an assessment of operations resources and processes leads to a view of operations capability.

FRAMEWORK FOR OPERATIONS STRATEGY

In operations strategy formulation, an iterative framework that links together the corporate objectives: which supply the organisational direction and marketing strategy; which define how the organisation will compete in its chosen markets, and the operations strategy; which provide capability to compete in those markets. The framework consists of five steps:

1. Define corporate objectives.
2. Determine marketing strategies to meet these objectives.
3. Assess how different products win orders against competitors.
4. Establish the most appropriate mode to deliver these sets of products.
5. Provide the infrastructure required to support operations.

Any mismatches between the requirements of the organisation's strategy and the operations capability can be revealed. A link between corporate marketing proposals and the operations processes is provided as well as infrastructure necessary to support them. This is achieved by translating the marketing strategy into a range of competitive factors (for example price, quality, delivery speed) on which the product or service wins orders. These external competitive factors provide the most important indicator as to the relative importance of the internal operations performance objectives.

The following types of competitive factors aid in securing customer orders in the marketplace:

- **Order-winning factors:** these are factors which contribute to winning business from customers. They are key reasons for customers purchasing the goods or services and raising the performance of the order-winning factor may secure more business.
- **Qualifying factors:** these are factors which are required in order to be considered for business from customers. Performance of qualifying factors must be at a certain level to gain business from customers, but performance above this level will not necessarily gain further competitive advantage.

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TOPIC 5

OPERATIONS DECISION MAKING

Introduction

Decision making essentially involves choosing a particular course of action, after considering the possible alternatives. Scientific decision-making rests upon organized principles of knowledge and depends largely upon the collection of empirical data and analysis of the data in a way that repeatable results will be obtained. Management use scientific method involves drawing objective conclusions from the facts. Facts come from the analysis of data, which must be gathered, compiled and digested into meaningful form, such as graphs and summary statistics. Computers are helpful in these tasks because they can easily store and use data with the more sophisticated and statistical analysis. But not all variables are quantifiable, so decision-makers must still use some value-based judgments in a decision process. Thus management as a science is characterised by:

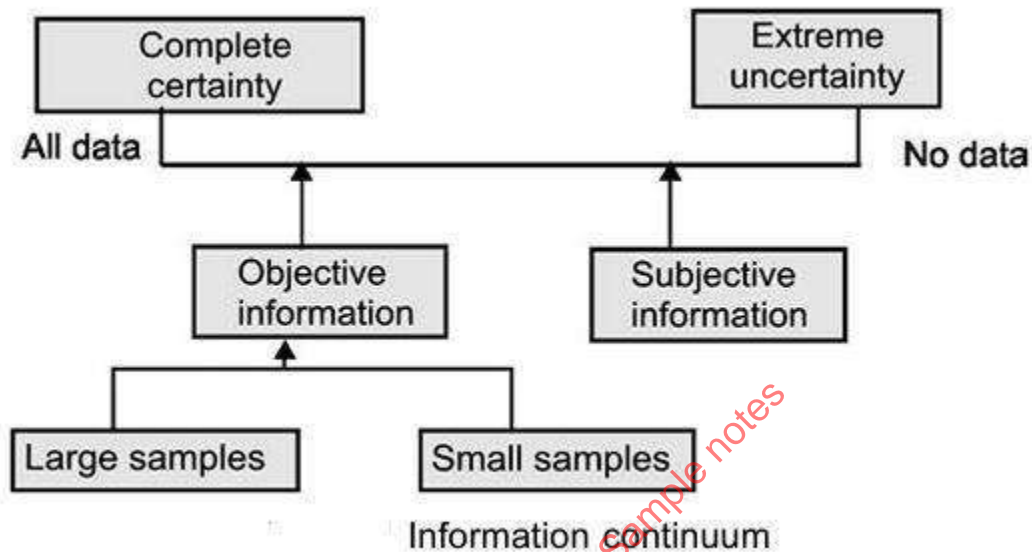
- Organised principle of knowledge
- Use of empirical data
- Systematic analysis of data
- Repeatable results

CHARACTERISTICS OF OPERATIONS DECISIONS

i. MANAGEMENT AS A SCIENCE

Operations decision range from simple judgments to complex analyses, which also involves judgment. Judgment typically incorporates basic knowledge, experience, and common sense. They enable to blend objectives and sub-objective data to arrive at a choice. The appropriateness of a given type of analysis depends on the significant or long lasting decisions the time availability and the cost of analysis, and the degree of complexity of the decision. The significant or long lasting decisions deserve more considerations than routine ones. Plant investment, which is a long-range decision, may deserve more thorough analysis. The time availability and the cost of analysis also influence the amount of analysis. The degree of complexity of the decision increases when many variables are involved, variables are highly independent and the data describing the variables are uncertain. Business decision-makers have always had to work with incomplete and uncertain data. In some situations a decision maker has complete information about the decision variables; at the other extremes, no information is available. Operations

management decisions are made all along this continuum. Complete certainty in decision-making requires data on all elements in the population. If such data are not available, large samples lend more certainty than do small ones. Beyond this, subjective information is likely to be better than no data at all. Below depicts the information environment of decisions.



ii. FRAMEWORK FOR DECISION-MAKING

An analytical and scientific framework for decision implies the following systematic steps

- Defining the problem
- Establish the decision criteria
- Formulation of a model
- Generating alternatives
- Evaluation of the alternatives
- Implementation and monitoring.

i. Defining the problem

Defining the problem enables to identify the relevant variables and the cause of the problem. Careful definition of the problem is crucial. Finding the root cause of a problem needs some questioning and detective work. If a problem defined is too narrow, relevant variable may be

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TOPIC 6

PRODUCTION MANAGEMENT AND RESOURCE PLANNING

CONCEPT AND OBJECTIVES OF PRODUCTION MANAGEMENT

Production management is a process of planning, organizing, directing and controlling the activities of the production function. It combines and transforms various resources used in the production subsystem of the organization into value added product in a controlled manner as per the policies of the organization.

Objectives of Production Management

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

1. Right quality

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

2. Right quantity

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

3. Right time

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

4. Right manufacturing cost

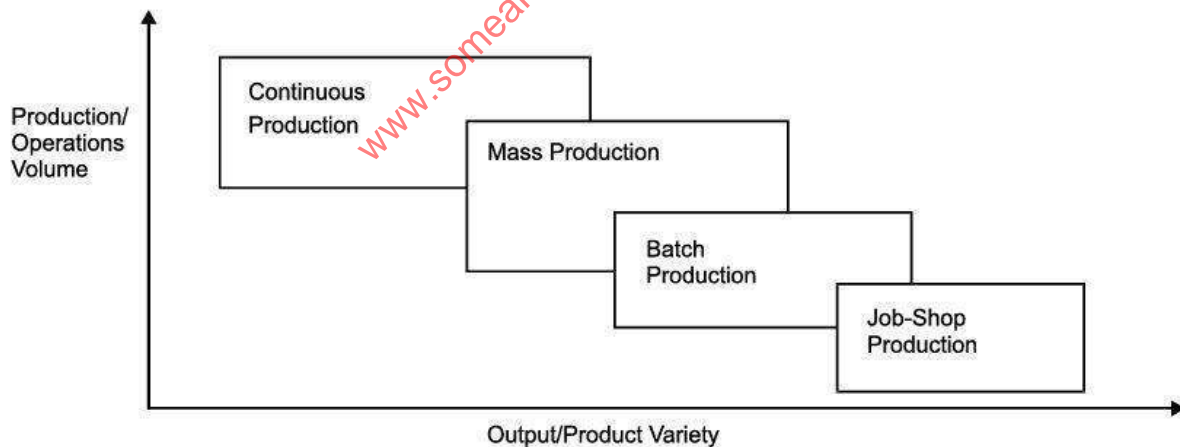
Manufacturing costs are established before the product is actually manufactured. Hence, all attempts should be made to produce the products at pre-established cost, so as to reduce the variation between actual and the standard (pre-established) cost.

CLASSIFICATION OF PRODUCTION SYSTEMS

The production system of an organization is that part, which produces products of an organization. It is that activity whereby resources, flowing within a defined system, are combined and transformed in a controlled manner to add value in accordance with the policies communicated by management.

The production system has the following characteristics:

1. Production is an organized activity, so every production system has an objective.
2. The system transforms the various inputs to useful outputs.
3. It does not operate in isolation from the other organization system.
4. There exists a feedback about the activities, which is essential to control and improve system performance.



Classification of production systems

1. Job-Shop Production

This is the oldest method of production on a very small scale. Job shop production are characterized by manufacturing of one or few quantity of products designed and produced as per the specification of customers within prefixed time and cost. The distinguishing feature of this is low volume and high variety of products. With this method individual requirements of consumers can be met. Each job order stands alone and may not be repeated.

A job shop comprises of general purpose machines arranged into different departments. Each job demands unique technological requirements, demands processing on machines in a certain sequence.

Characteristics

The Job-shop production system is followed when there is:

1. Known for rapid value addition
2. High variety of products and low volume
3. Use of general purpose machines and facilities
4. Highly skilled operators who can take up each job as a challenge because of uniqueness
5. Large inventory of materials, tools, parts
6. It deals with 'low volume and large variety' production.
7. Detailed planning is essential for sequencing the requirements of each product, capacities for each work center and order priorities.
8. This system has a lot of flexibility of operation, and hence general purpose machines are required

Following are the advantages of job shop production:

1. Because of general purpose machines and facilities variety of products can be produced.
2. Requires less money and is easy to start with
3. Operators will become more skilled and competent, as each job gives them learning opportunities.
4. Less or no management problem because of very small work force.
5. Full potential of operators can be utilized.
6. Opportunity exists for creative methods and innovative ideas.

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TOPIC 7

SYSTEMS DESIGN

MANUFACTURING AND SERVICE SYSTEMS

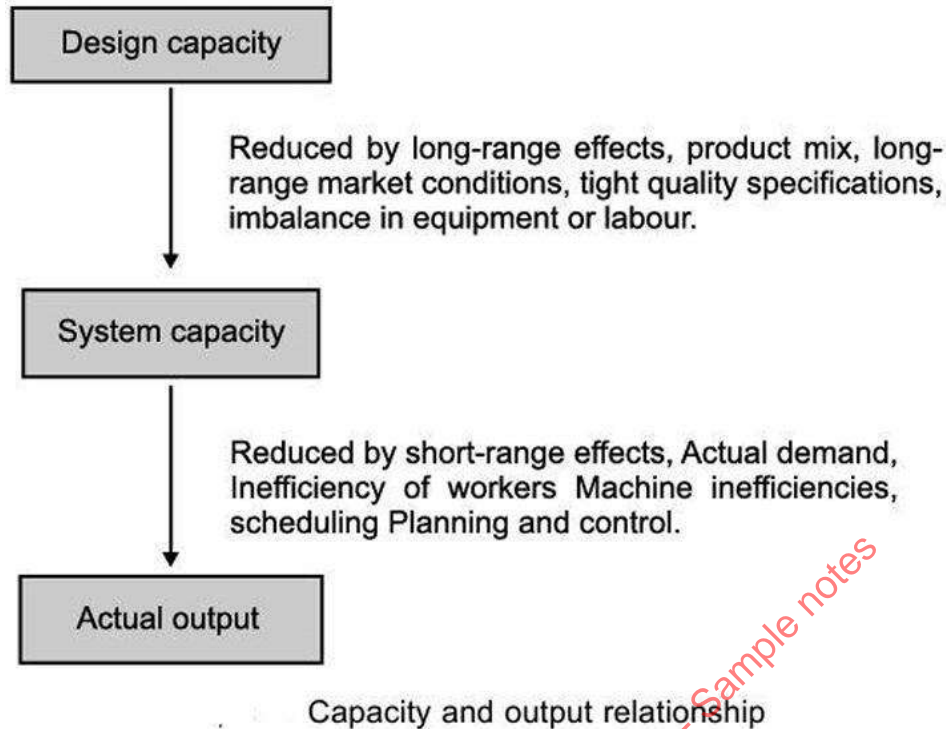
Manufacturing and service systems are arrangements of facilities, equipment, and people to produce goods and services under controlled conditions.

Manufacturing systems produce standardized products in large volumes. This plant and machinery have a finite capacity and contribute fixed costs that must be borne by the products produced. Variable costs are added as labour is employed to combine or process the raw materials and other components. Value addition will take place during the production process for the product. The cost of output relative to the cost of input can be measured, as the actual cost is known i.e. productivity is measurable quantity.

Service systems present more uncertainty with respect to both capacity and costs. Services are produced and consumed in the presence of the customer and there is little or no opportunity to store value, as in a finished goods inventory. As a result capacity of service systems like hospitals, restaurants and many other services must be sufficiently flexible to accommodate a highly variable demand. In addition, many services such as legal and medical involves professional or intellectual services judgments that are not easily standardized. This makes more difficult to accumulate costs and measure the productivity of the services.

DESIGN AND SYSTEM CAPACITY

Production systems design involves planning for the inputs, transformation activities, and outputs of a production operation. Design plays a major role because they entail significant investment of funds and establish cost and productivity patterns that continue in future. The capacity of the manufacturing unit can be expressed in number of units of output per period. In some situations measuring capacity is more complicated when they manufacture multiple products. In such situations, the capacity is expressed as man-hours or machine hours. The relationship between capacity and output is shown below.



DESIGN CAPACITY

Designed capacity of a facility is the planned or engineered rate of output of goods or services under normal or full scale operating conditions. For example, the designed capacity of the cement plant is 100 TPD (Tonnes per day). Capacity of the sugar factory is 150 tonnes of sugarcane crushing per day. The uncertainty of future demand is one of the most perplexing problems faced by new facility planners. Organisation does not plan for enough regular capacity to satisfy all their immediate demands. Design for a minimum demand would result in high utilisation of facilities but results in inferior service and dissatisfaction of customers because of inadequate capacity. The design capacity should reflect management's strategy for meeting the demand. The best approach is to plan for some in-between level of capacity.

System/effective capacity: System capacity is the maximum output of the specific product or product mix the system of workers and machines is capable of producing as an integrated whole. System capacity is less than design capacity or at the most equal it because of the limitation of product mix, quality specification, and breakdowns. The actual is even less because of many factors affecting the output such as actual demand, downtime due to machine/equipment failure, unauthorized absenteeism. The system capacity is less than design capacity because of long-

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TOPIC 8

FACILITY LOCATION AND LAYOUT

FACILITY LOCATION

Plant location may be understood as the function of determining where the plant should be readied for maximum operating economy and effectiveness. The selection of a place for locating a plant is one of the problems, perhaps the most important, which is faced by an entrepreneur while launching a new enterprise. A selection on pure economic considerations will ensure an easy and regular supply of raw materials, labour force, efficient plant layout, proper utilisation of production capacity and reduced cost of production. An ideal location may not, by itself, guarantee success; but it certainly contributes to the smooth and efficient working of an organisation. A bad location, on the other hand, is a severe handicap for any enterprise and it finally bankrupts it. It is, therefore, very essential that utmost care should be exercised in the initial stages to select a proper place. Once a mistake is made in locating a plant it becomes extremely difficult and costly to correct it.

FACTORS THAT DETERMINE THE LOCATION OF OPERATING UNITS

To be systematic, in choosing a plant location, the entrepreneur would do well to proceed step by step, the steps include:

1. Within the country or outside;
2. Selection of the region;
3. Selection of the locality or community;
4. Selection of the exact site.

1. Deciding on Domestic or International Location

The first step in plant location is to decide whether the facility should be located domestically or internationally.

A few years ago, this factor would have received little consideration. But with increasing internationalization of business, the issue of home or foreign country' is gaining greater relevance. If the management decides on foreign location, the next logical step would be to decide upon a particular country for location. This is necessary because, countries across the world are vying with each other to attract foreign investments. The choice of a particular country depends on such factors as political stability, export and import quotas, currency and exchange rates, cultural and economic peculiarities, and natural or physical conditions.

2. Selection of Region

The selection of a particular region out of the many natural regions of a country is the second step in plant location.

The following factors influence such selection:

(i) Availability of Raw Materials

As a manufacturing unit is engaged in the conversion of raw materials into finished products, it is very essential that it should be located in a place where the supply of raw materials is assured at minimum transport cost. The sugar industry, the paper industry, the iron and steel industry, the industries engaged in the solvent extraction of oil from rice bran, the China clay washery, factories manufacturing low tension porcelain insulators, and the like should be located near the sources of their raw materials.

Nearness to raw materials offers such advantages as:

- a) Reduced cost of transportation;
- b) Regular and proper supply of materials uninterrupted by transportation breakdowns;
and
- c) Savings in the cost of storage of materials.

(ii) Nearness to the Market

Since goods are produced for sale, it is very essential that the factory should be located near their market. A reduction in the cost of transporting finished goods to the market; the ability to adjust the production programme to suit the likes and dislikes of consumers; the ability to render prompt service to the consumers, provide after-sale services, and execute replacement orders without delay - these are some of the advantages that accrue to the entrepreneur if he/she establishes his/her factory near his market.

(iii) Availability of Power

Power is essential to move the wheels of an industry. Coal, electricity, oil and natural gas are the sources of power.

Where coal is the source of power, as in the case of the iron and steel industry, the factory has to be located near the coal fields. Examples of such industries are: the iron and steel industry in Germany, in Pennsylvania in the U.S.A. and in Jamshedpur in India.

(iv) Transport Facilities

While making a study of a location, an entrepreneur considers the question of the availability of transport facilities.

Transport facilities are essential for bringing raw materials and men to the factory and for carrying the finished products from the factory to the market. A place which is well connected rail, road and water transport is ideal for a plant location. It may be said that industry follows transportation. In other words, places with well-developed means of transport attract industries. In extreme cases, transport may follow industries. For instance, if a public sector unit is started in a remote place, the Government will naturally provide transport facilities to cater to the requirements of the unit. But, generally speaking a place with existing transport facilities is perfect for locating a plant.

(v) Suitability of Climate

The climate has its own importance in the location of a plant because of two reasons. First, there are certain industries which, because of the nature of their production, require particular climatic conditions; for example, humid climate for cotton textiles and jute. Such industries have to be located in places where humid climatic conditions are available.

(vi) Government Policy

The influence of Government policies and programmes on plant location is apparent in every country, particularly in planned economies like ours. In the name of balanced regional development, many backward regions in India have been selected for the location of new industries, which would generate the region's economy and on a larger canvas, the national economy.

The Government influences plant location in a number of ways. Some of these are:

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TOPIC 9

TOTAL QUALITY MANAGEMENT (TQM)

Quality may be defined as the sum total of features of a product which influence its ability to satisfy a given demand.

Dimensions of Product Quality: Some dimensions of product quality are:

- i. **Performance:** How will the product or service perform and meet the customer's intended use. For example, the speed of a sports car.
- ii. **Features:** The special characteristics that appeal to customers. For example, the power steering of an automobile.
- iii. **Reliability:** The likelihood of breakdowns, malfunctions, or need for repairs. Higher the reliability lesser will be the likelihood of breakdowns and malfunctions and better will be the quality of the product.
- iv. **Serviceability:** The speed, cost and convenience of repairs and maintenance. Higher the serviceability better will be the quality of the product.
- v. **Appearance:** The effect on human senses, the look, feel, taste, smell or sound.
- vi. **Customer Service:** The treatment received by customers before, during and after the sale.
- vii. **Safety:** How well the product protects users before, during and after use.

Total Quality Management

Total Quality Management (TQM) is a philosophy and approach which aims to ensure that high quality, as defined by the customer, is a primary concern throughout an organisation and all parts of an organisation work towards this goal. TQM does not prescribe a number of steps that must be followed in order to achieve high quality but rather should be considered a framework within

which organisations can work. The TQM process will be dependent on factors such as customer needs, employee skills and the current state of quality management within an organisation.

The six basic concepts of TQM

1. A committed and involved management to provide long-term top-to-bottom organisation support.
2. An unwavering focus on the customer, both internally and externally.
3. Effective involvement and utilisation of the entire workforce.
4. Continuous improvement of the business and production process.
5. Treating suppliers as partners.
6. Establish performance measures for the process.

Total quality management stresses on three principles:

- i. Customer satisfaction.
 - ii. Employee involvement.
 - iii. Continuous improvements in quality.
- **Customer satisfaction** is a relative concept that varies from one customer to another. Also, a customer may be satisfied with today's products but not satisfied in the future. For example, while one customer may consider a Ford automobile perfectly satisfactory, another may not. Each person defines quality in relation to his or her own needs and means at a particular point of time.
 - **Employee involvement** in quality management is crucial in achieving and sustaining high levels of quality. Employees may have to be empowered to take preventive and if necessary corrective actions without management approval. Employees must be involved in quality management by encouraging them to use quality control tools and techniques to track performance and identify areas needing improvement. Employee training and motivation are essential for achieving and sustaining high levels of service quality.
 - **Continuous improvement** is a never ending process and is driven by knowledge and problem solving from the producer's viewpoint; variation from specifications cannot be tolerated. The producer must specify quality attributes of the product or service as carefully as possible and then strive to meet those specifications. While improving the process overtime, producers should continuously strive to improve quality, that is doing a better job of meeting customer needs by reducing variability in all processes and by introducing new

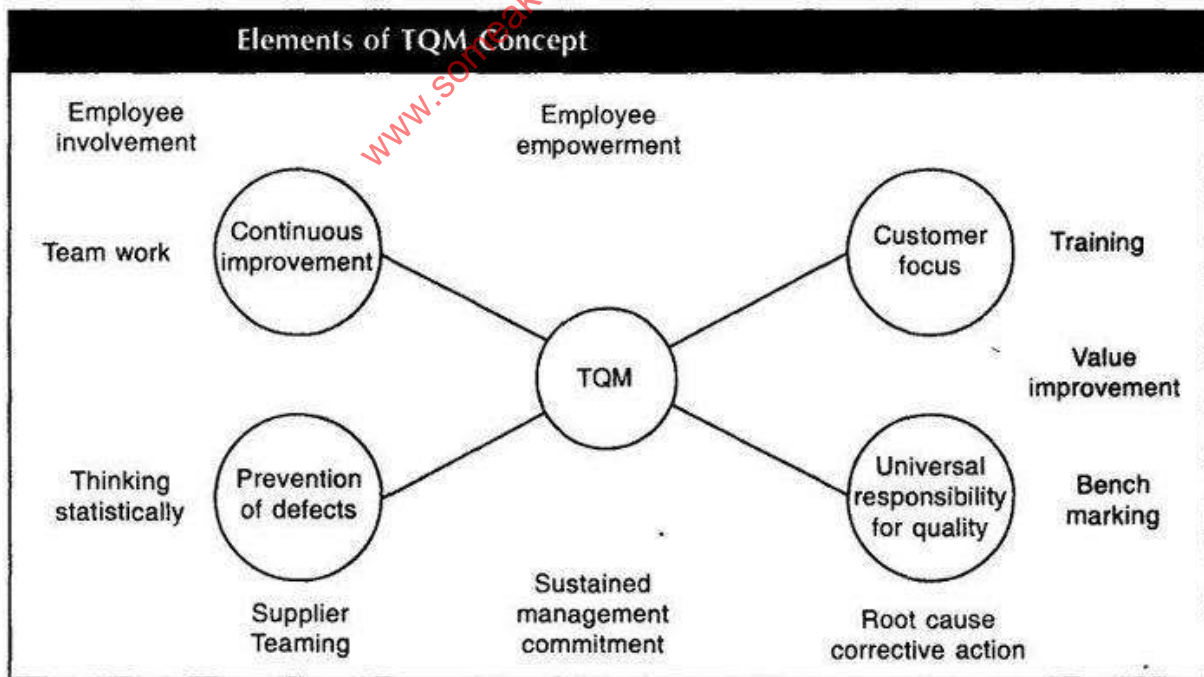
products when needed. As producers gain a better understanding of customer expectations and as better technology becomes available, quality can be continuously improved.

Additional principles of TQM include:

Primary responsibility for product quality rests with top management.

- i. Quality should be customer-focused and evaluated using customer-based standards.
- ii. The production process and work methods must be designed consciously to achieve quality of conformance.
- iii. Quality cannot be inspected into a product. So make it right the first time.
- iv. Quality must be monitored to identify problems quickly and correct quality problems immediately.
- v. Companies must work with and extend TQM programs to their suppliers to ensure quality inputs.

Elements of TQM



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TOPIC 10

BENCHMARKING IN OPERATIONS MANAGEMENT

MEANING OF BENCHMARKING

Benchmarking is the process of comparing the cost, cycle-time, productivity, or quality of a specific process/method to another that is widely considered to be an industry standard or leading practice.

Similar to a balance sheet, benchmarking provides a snap-shot of performance measurement at a point in time, and needs to be re-measured on an ongoing basis

Strategically, benchmarking provides a baseline today for growth tomorrow. Executives use this business data and analysis to drive strategic decisions and initiatives. The continuous monitoring of the metrics associated with the strengths and deficiencies of business processes or systems allows organizations to focus on the right levers for growth. Benchmarking shows the value associated with any improvements, efficiencies and cost reductions gained, which can translate into increased profit.

Organizations also use benchmarking for trend analysis and target setting as part of their annual strategic planning process. Established baseline measurements enable decision makers to better plan and align business initiatives with corporate strategy. The metrics and insights derived from benchmarking provide the quantitative evidence into the effectiveness of critical business processes or operations. This information enables managers to proactively craft solutions to address issues which increase efficiencies and reduce cost. Benchmarks become the visible line in the sand against which incremental improvements are measured, as manager's drive toward their targets.

Benchmarks can also be used to improve employee performance. While process improvement and benchmarking sometimes have a negative connotation for employees (such as layoffs resulting from efficiency gains), they provide an educational opportunity if communicated correctly. The baseline data serves as a report card for employees letting them know how processes and systems are performing while also setting expectations for future improvements. In addition to inciting a competitive desire to improve, employees should also be encouraged to work smarter, not harder. Employees tend to respond better with a deeper understanding of the root cause and quantitative value derived from the data, thus allowing emotions and egos to remain in check.

Benchmarking Process

- 1. Planning and Setting the Scope and Goals.** Success comes in the planning. When deciding which benchmarking projects to undertake, a cost-benefit analysis is useful. Again, benchmarking identifies which processes and systems need attention and provides both data and metrics used to calculate savings. While the cost may be based on a technology solution or process improvement, the savings are based on improved performance—for example; the cost to process an invoice is reduced from \$25 to \$15 for an estimated savings of \$1.2M annually (\$10 x 120,000 invoices processed). The information contained in the chart provides a useful visualization of the data and helps facilitate discussion and decision making when developing a plan.

Additionally, be sure to set the scope by determining the metrics, the people involved, the systems used, and steps involved in the process. Detailed planning enables the benchmarking team to develop the right recommendations that lead to cost reductions and increased control over the process.

- 2. Collect the Data.** The best approach towards business improvement services starts by understanding the existing processes and systems. The data collected includes any quantitative data specific for the business function, the steps involved in the process, and who in the process executes the steps, including when and how. In addition, the data must be collected in a manner consistent with the benchmarking data and guidelines. For example, the procurement function can be performed as a centrally managed function within a single department; however, the benchmarking data may include company-wide efforts in the procurement process and not just the procurement department's effort. If the organization's data and the benchmarking data are inconsistent, then results will not be relevant and the analysis may prove contradictory.
- 3. Analyze the Data.** With an understanding of the existing people, processes, and technology involved in the process being analyzed, the metrics are analyzed and compared against different peer group benchmarks. The analysis should answer the following questions: What do the metrics mean? How do these findings relate to similar findings? What do the results mean? What conclusions can be drawn? Where should improvement resources be devoted to receive the largest impact? Analyzing and understanding your data will help develop a roadmap detailing solution alternatives with the appropriate steps and best practices to achieve the recommended state. With these answers in hand, a visual cost-benefit analysis can be drawn to help show how to prioritize projects.

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TOPIC 11

PRODUCT AND SERVICE DESIGN

PRINCIPLES OF PRODUCT AND SERVICE DESIGN

A good product design must ensure the following:

- i. **Function or performance:** The function or performance is what the customer expects the product to do to solve his/her problem or offer certain benefits leading to satisfaction. For example, a customer for a motor bike expects the bike to start with a few kicks on the kick peddle and also expects some other functional aspects such as pick- up, maximum speed, engine power and fuel consumption etc.
- ii. **Appearance or aesthetics:** This includes the style, colour, look, feel, etc. which appeals to the human sense and adds value to the product.
- iii. **Reliability:** This refers to the length of time a product can be used before it fails. In other words, reliability is the probability that a product will function for a specific time period without failure.
- iv. **Maintainability:** Refers to the restoration of a product once it has failed. High degree of maintainability is desired so that the product can be restored (repaired) to be used within a short time after it breaks down. This is also known as serviceability.
- v. **Availability:** This refers to the continuity of service to the customer. A product is available for use when it is in an operational state. Availability is a combination of reliability and maintainability. High reliability and maintainability ensures high availability.
- vi. **Producibility:** This refers to the ease of manufacture with minimum cost (economic production). This is ensured in product design by proper specification of tolerances, use of materials that can be easily processed and also use of economical processes and equipment to produce the product quickly and at a cheaper cost.
- vii. **Simplification:** This refers to the elimination of the complex features so that the intended function is performed with reduced costs, higher quality or more customer satisfaction. A

simplified design has fewer parts which can be manufactured and assembled with less time and cost.

- viii. **Standardisation:** Refers to the design activity that reduces variety among a group of products or parts. For example, group technology items have standardised design which calls for similar manufacturing process steps to be followed. Standard designs lead to variety reduction and results in economies of scale due to high volume of production of standard products. However, standardised designs may lead to reduced choices for customers.
- ix. **Specification:** A specification is a detailed description of a material, part or product, including physical measures such as dimensions, volume, weight, surface finish etc. These specifications indicate tolerances on physical measures which provide production department with precise information about the characteristics of products to be produced and the processes and production equipment to be used to achieve the specified tolerances (acceptable variations) . Interchangeability of parts in products produced in large volumes (mass production and flow-line production) is provided by appropriate specification of tolerances to facilitate the desired fit between parts which are assembled together.
- x. **Safety:** The product must be safe to the user and should not cause any accident while using or should not cause any health hazard to the user. Safety in storage, handling and usage must be ensured by the designer and a proper package has to be provided to avoid damage during transportation and storage of the product. For example, a pharmaceutical product while used by the patient, should not cause some other side effect threatening the user.

Source of new product and service design

- **Customer requirements:** The designers must find out the customers to ensure that the products suit the convenience products must be designed to be used in all kinds of conditions exact requirements of the of customers for use.
- **The Convenience of the operator or user:** The industrial products such as machines and tools should be so designed that they are convenient and comfortable to operate or use.
- **Trade-off between function and form:** The design should combine both performance and aesthetics or appearance with a proper balance between the two.

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TOPIC 12

MAINTENANCE MANAGEMENT

Maintaining the production capability of an organisation is an important function of production and operations management in any production system. Maintenance refers to the upkeep and protection of plant, building, machinery, and other fixed assets of a firm which are subject to deterioration due to their use and exposure to environmental conditions over a period of time. Maintenance encompasses all those activities required to keep the physical facilities and equipment in good working condition and making necessary repairs when breakdowns occur, so that the system can perform as intended.

Two categories of maintenance activities in a firm are:

- (i) Maintaining buildings, parking lots, lawns, fences, services and utilities.
- (ii) Maintaining equipment, machinery, material handling equipment, transport vehicles, tools, metrology tools, (inspection gages), test instruments, office equipment (computer, fax, xerox machines) etc.

Maintenance is defined as "that function of production management that is concerned with the day-to-day problem of keeping the physical plant in good operating condition. It is an essential activity in every manufacturing firm, because it is necessary to ensure the availability of the machines, buildings and services needed by other parts of the organisation for the performance of their function at an optimum return on investment in machines, materials and employees". Maintenance management is concerned with the direction and organisation of resources in order to control the availability and performance of the industrial plants to some specified level. It is a function supporting production function and is entrusted with the task of keeping the machinery, equipment and plant services in proper working condition. It also involves maintenance planning, maintenance scheduling, execution of maintenance activities (repair, breakdown and preventive maintenance) and also controlling costs of maintenance.

Scope of Maintenance

Every manufacturing organisation needs maintenance because machines break down, parts wear out and buildings deteriorate over a period of time of use. All segments of a factory buildings, machinery, equipment, tools, cranes, jigs and fixtures, heating and generating equipment, waste

disposal systems, air-conditioning equipment, wash rooms, dispensaries and so on need attention. . Maintenance covers two broad categories of functions as outlined below.

A. Primary functions

- i. Maintenance of existing plant and equipment.
- ii. Maintenance of existing plant buildings and grounds.
- iii. Equipment inspection and lubrication.
- iv. Utilities generation and distribution.
- v. Alterations to existing equipment and buildings.
- vi. New installations of equipment and buildings.

B. Secondary functions

- i. Store keeping (keeping stock of spare parts)
- ii. Plant protection including fire protection.
- iii. Waste disposal.
- iv. Salvage.
- v. Insurance administration (against fire, theft, etc.)
- vi. Janitorial services.
- vii. Property accounting
- viii. Pollution and noise abatement or control.
- ix. Any other service delegated to maintenance by plant management.

IMPORTANCE OF MAINTENANCE MANAGEMENT

1. Dependability of service is one of the performance measures by which a company can distinguish itself from others. To establish a competitive edge and to provide good customer service, companies must have reliable equipment that will respond to customer demand when needed. Equipment must be kept in reliable condition without costly work stoppage and down time due to repairs if the company is to remain productive and competitive.
2. Maintenance is an important factor in quality assurance which is another basis for successful competitive edge. Inconsistencies in equipment lead to variability in product characteristics and result in defective parts that fail to meet the established specifications. Beyond just preventing break downs, it is necessary to keep equipment operating within specifications (i.e., process capability) that will produce high level of quality.

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TOPIC 13

AUTOMATION

Automation is a technology concerned with the application of mechanical, electronic, and computer based systems to operate and control production. This technology includes automatic machine tools to process parts, automatic assembly machines, industrial robots, automatic material handling and storage systems, automatic inspection systems for quality control, feedback control and computer process control, computer systems for planning, data collection and decision-making to support manufacturing activities.

1. Fixed Automation

It is a system in which the sequence of processing (or assembly) operations is fixed by the equipment configuration. The operations in the sequence are usually simple. It is the integration and coordination of many such operations into one piece of equipment that makes the system complex. The typical features of fixed automation are:

- a. High initial investment for custom-Engineered equipment;
- b. High production rates; and
- c. Relatively inflexible in accommodating product changes. The economic justification for fixed automation is found in products with very high demand rates and volumes. The high initial cost of the equipment can be spread over a very large number of units, thus making the unit cost attractive compared to alternative methods of production. Examples of fixed automation include mechanized assembly and machining transfer lines.

2. Programmable Automation

In this the production equipment is designed with the capability to change the sequence of operations to accommodate different product configurations. The operation sequence is controlled by a program, which is a set of instructions coded so that the system can read and interpret them. New programs can be prepared and entered into the equipment to produce new products. Some of the features that characterise programmable automation are:

- a. High investment in general-purpose equipment;
- b. Low production rates relative to fixed automation;
- c. Flexibility to deal with changes in product configuration; and
- d. Most suitable for batch production.

Automated production systems that are programmable are used in low and medium volume production. The parts or products are typically made in batches. To produce each new batch of a different product, the system must be reprogrammed with the set of machine instructions that correspond to the new product. The physical setup of the machine must also be changed over: Tools must be loaded, fixtures must be attached to the machine table also be changed machine settings must be entered. This changeover procedure takes time. Consequently, the typical cycle for given product includes a period during which the setup and reprogramming takes place, followed by a period in which the batch is produced. Examples of programmed automation include numerically controlled machine tools and industrial robots.

3. Flexible Automation

It is an extension of programmable automation. A flexible automated system is one that is capable of producing a variety of products (or parts) with virtually no time lost for changeovers from one product to the next. There is no production time lost while reprogramming the system and altering the physical setup (tooling, fixtures, and machine setting). Consequently, the system can produce various combinations and schedules of products instead of requiring that they be made in separate batches. The features of flexible automation can be summarized as follows:

- a. High investment for a custom-engineered system.
- b. Continuous production of variable mixtures of products.
- c. Medium production rates
- d. Flexibility to deal with product design variation

The essential features that distinguish flexible automation from programmable automation are:

1. The capacity to change part programs with no lost production time; and
2. The capability to change over the physical setup again with no lost production time

These features allow the automated production system to continue production without the downtime between batches that is characteristic of programmable automation. Changing the part programs is generally accomplished by preparing the programs off-line on a computer system and electronically transmitting the programs to the automated production system. Therefore, the time required to do the programming for the next job does not interrupt production on the current job. Advances in computer system technology are largely responsible for this programming capability in flexible automation. Changing the physical setup between parts is accomplished by making the changeover off-line and then moving it into place simultaneously as the next part comes into position for processing. The use of pallet fixtures that hold the parts and transfer into position at the workplace is one way of implementing this approach. For these approaches to be successful; the variety of parts that can be made on a flexible automated production system is usually, more limited that a system controlled by programmable automation.

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