Mount Kenya University

UNIT CODE: MBM6140:

UNIT TITLE: PRODUCTION OPERATIONS MANAGEMENT

COURSE OUTLINE
Contact hours: 42

Purpose: To provide a comprehensive skills to enable learners understand objectives, organization systems and structures, techniques of handling all activities in production & operations management.

Expected learning outcomes of the course:

By the end of the course the student should be able to:

i. Describe the concepts and principles of Operations Management

ii. Discuss Production and Operations Management as an interdisciplinary function.

iii. Explain the significance of production processes and process change

iv. Assess the importance of planning and control in a production environment

Week 1: **INTRODUCTION TO OPERATIONS MANAGEMENT**
Definition of operation management
Differences between manufacturing and service operations
Organization of operations management
Objectives of operations management

Week 2: **PRODUCT DESIGN PROCESS AND PRODUCTION PROCESS CHOICE**
Product design process
Production Process Selection
Environmentally friendly product design
Contributions Of Purchasing And Supply In Design Of Product And Services
Operations as a part of demand and supply networks

Week 3: **FACILITY LOCATION AND LAYOUT**
Facility Location
Location Factors
Layout Design
Principles of job design and ergonomics
Methods Analysis
Motion Study
Work Measurement
Time Study
Predetermined Motion Times
Work Sampling
Ergonomics

Week 4: **INVENTORY MANAGEMENT**
Types of inventory

Types of Demand
Functions of Inventory
Effects of inadequate inventory controls
Objectives of Inventory Management
Requirements for Effective Inventory Management
Stock taking systems
Demand Forecast and Lead time Information
Inventory Cost
Inventory Decisions
Safety Stock and Service Level
The ABC Inventory Classification System

Week 5: ASSET MAINTENANCE AND MANAGEMENT

Asset management
Objectives of asset management
Asset management plan
Components of an asset management system
Asset maintenance
Asset Maintenance Plan
Asset maintenance strategies

Week 6: Quality control and appraisal techniques

Dimensions of quality
Quality planning
Quality costs
Analysis techniques of quality cost
Quality systems
Total quality management (tqm)
Statistical process control (spc)
Six sigma
The dmaic methodology

Week 7: CAPACITY PLANNING

Identifying Capacity Requirements
Measuring Demand
Evaluating Capacity Plans
Measuring Capacity
Level Capacity
Chase Demand
Demand Management

Week 8: LEAN OPERATIONS AND JUST IN TIME (JIT) MANAGEMENT

Types of waste
Just-in-time (JIT) production
Key Elements of JIT

Week 8: **BUSINESS PROCESS REENGINEERING (BPR)**

Components of business process re-engineering definition

Implementing business process redesign

WEEK 9: OPERATIONS PLANNING AND CONTROL

Benefits of planning and control
Constraints on the planning and control task
Steps in the planning and control
Production control
Production Planning

Week 10: **PROJECT MANAGEMENT**

Project Management Activities
Network Analysis
Gantt charts

Week 11: **BENCHMARKING**

Key performance indicators
Types of benchmarking
Process of benchmarking
Advantages of benchmarking
Disadvantages of benchmarking
World class operations
Guidelines for effective benchmarking and achieving world class operations

Week 12: **FAILURE PREVENTION AND RECOVERY**

Types of failure
Techniques of measuring failure
Failure detection and analysis
Failure Analysis
Improving operations Reliability/Ways of reducing failure

ROLE OF IT IN OPERATIONS MANAGEMENT

Recommended Text Books:

i. Adams E. E. (2007), production and operations management, 5th Edition,Prentice Hall, Chicago
ii. Barey Render (2004), Principles of operations Management, Prentice Hall, New Jersey
iii. Franklin G. Moore (2002), Production Operations Management, Irwin, Illinois
Muhlenn A. (2007), Production and Operations Management, PVT Publishers, New Delhi

Text book for further reference

i. S. Anill, N. Suresh. (2006), Production and Operations Management, New Age Publisher, New

ii. William Sterenson (1999), Production Operations Management, McGraw Hill, London

Table of Contents

INTRODUCTION TO OPERATIONS MANAGEMENT

Objectives:

By the end of the chapter the student should be able to:

(i) Define the term operations management
(ii) Distinguish between manufacturing and service operations
(iii) Outline the organization of operations management
(iv) Explain the objectives of operations management

Introduction

Operations Management is the activity of managing the resources of an organisation which produce and deliver goods and services. Operations can be seen as one of many functions (e.g. marketing, finance, personnel) within the organisation. The operations function can be described as that part of the organisation devoted to the production or delivery of goods and services. This means all organisations undertake operations activities because every organisation produces goods and/or services.

Alternatively Operations management can also be defined as the design, improvement, and the management of the transformation processes that create value by converting inputs, such as raw materials, labor, and/or customer into outputs, such as goods or services

Manufacturing and Service Operations

Organisations can be classified in two broad categories as either manufacturing or service. Manufacturing organisations produce physical, tangible items which can be stored as inventory before delivery to the customer. Service organisations produce intangible items that cannot be produced ahead of time. One of the key developments in operations is the increasing importance of service operations as service industry accounts for an increasing proportion of the output of industrialised economies. Service operations management is the term that is used to cover the activities, decisions and responsibilities of operations managers in service organizations.

Differences between manufacturing and service organisation

(i) Because a service cannot be stored its production and consumption will occur at the same time that implies that the producer of the service will come into contact with the customer. However for a manufacturing concern production can be stored and personal contact between supplier and the customer is not necessary

(ii) Because services are intangible then it follows that they cannot have a store for finished goods. Manufacturing operations will often compensate for fluctuations in demand by fulfilling demand from finished goods inventory produced during a slack period. This option is not open to service operations and they must focus on trying to alter the demand pattern to meet capacity by such strategies as discounting the price of the service during periods of low demand. Because the output of a service is intangible it is more difficult to assess performance by such measures as productivity or output. For example a manufacturer can simply count the volume of output of its product range, but an administration service for example will have more difficulty in measuring the productivity of their employees.

(iii)The quality of a service will be judged by the process of delivering that service as well as the quality of any tangible goods that are involved. This leads to the problem that it is more difficult to measure the quality of service delivery than the quality of manufactured goods. In reality most operations systems produce a mixture of goods and services.

(iv) Most goods have some supporting service element (e.g. a maintenance facility), called a facilitating service, while many services will have supporting goods (e.g. a management consultancy report), termed a facilitating good.

(v) For the manufacturing sector product definition is consistent while in the service the product definition is inconsistent

The Organisation Of Operations Management

The organization of operations management can be categorized into three specific levels:

(i). strategic/top level/longterm management

(ii). Tactical/functional/medium term/middle level management

(iii). Operational/shortterm management

The responsibilities of these levels of the management are:

Strategic management

This is the highest level of operations management. Generally they make decisions which have longterm consequences (more than three years) and which affect the organization as a whole. Their specific functions include Decisions about:

(i) Products to make (product development)

(ii) Make or buy decisions

(iii) How to make products (process and layout decisions)

(iv) How much to procure

(v) Production site location

(vi) How much capacity is needed. (high level capacity decisions)

Tactical management

This is the second level of management in operations. They make decisions related to specific functions or departments within the organization with medium term consequence (i.e. less than three years but more than one year). Their specific functions include:

(i). Addressing the material and labor resources within the Constraints.

(ii). Labour planning:how many workers are needed.

(iii). inventory and replenishment planning: level of stock required and when should it be delivered.

(iv). Determining shifts needed for work: Whether overtime or subcontractors are required

(v). detailed capacity planning

Operational management

These are the low level managers in operations. They make decisions related to the day to day functions of the organizations and whose consequence is shortterm(less than one year). Their specific functions include:

(i). Planning, execution and control decisions.

(ii). Scheduling: What to process and when

(iii). Sequencing: What is the order to process requirements

(iv). Loading:How does the work utilize the resources

(v). Assignments: Who does the work

Objectives Of Operations Management

Operations objectives are very broad. Operations management has an impact on the five broad categories of stakeholders in any organisation. Stakeholders is a broad term but is generally used to mean anybody who could have an interest in, or is affected by, the operation. The five groups are:

- Customers – the buyers of an organization's outputs. These are the most obvious people who will be affected by any business.
- Suppliers – the providers of an organization's inputs. Operations can have a major impact on suppliers, both on how they prosper themselves, and on how effective they are at supplying the operation.
- Shareholders – the owners of the organization. Clearly, the better an operation is at producing goods and services, the more likely the whole business is to prosper and shareholders will be one of the major beneficiaries of this.
- Employees – workers of the organization. Similarly, employees will be generally better off if the company is prosperous; if only because they are more likely to be employed in the future. However operations responsibilities to employees go far beyond this. It includes the general working conditions which are determined by the way the operation has been designed.
- Society – Although often having no direct economic connection with the company, individuals and groups in society at large can be impacted by the way its operations managers behave. The most obvious example is in the environmental responsibility exhibited by operations managers.

the general objectives of operations management are: quality, speed, dependability, flexibility, and cost.

Quality

Quality is believed to be the most important of all the objectives. quality is discussed largely in terms of it meaning 'conformance'. That is, the most basic definition of quality is that a product or service is as it is supposed to be. In other words, it conforms to its specifications.
There are two important points to remember when reading the section on quality as a performance objective.

- The external affect of good quality within in operations is that the customers who 'consume' the operations products and services will have less (or nothing) to complain about. And if they have nothing to complain about they will (presumably) be happy with their products and

services and are more likely to consume them again. This brings in more revenue for the company (or clients satisfaction in a not-for-profit organisation).

- Inside the operation quality has a different affect. If conformance quality is high in all the operations processes and activities very few mistakes will be being made. This generally means that cost is saved, dependability increases and (although it is not mentioned explicitly in the chapter) speed of response increases. This is because, if an operation is continually correcting mistakes, it finds it difficult to respond quickly to customers requests. See the figure below.

Speed

Speed is a shorthand way of saying 'Speed of response'. It means the time between an external or internal customer requesting a product or service, and them getting it. Again, there are internal and external affects.

- Externally speed is important because it helps to respond quickly to customers. Again, this is usually viewed positively by customers who will be more likely to return with more business. Sometimes also it is possible to charge higher prices when service is fast. The postal service in most countries and most transportation and delivery services charge more for faster delivery, for example.
- The internal affects of speed have much to do with cost reduction. Usually, faster throughput of information (or customers) will mean reduced costs. So, for example, processing passengers quickly through the terminal gate at an airport can reduce the turn round time of the aircraft, thereby increasing its utilisation.

Dependability

Dependability means 'being on time'. In other words, customers receive their products or services on time. In practice, although this definition sounds simple, it can be difficult to measure. What exactly is on time? Is it when the customer needed delivery of the product or service? Is it when they expected delivery? Is it when they were promised delivery? Is it when they were promised delivery the second time after it failed to be delivered the first time? Again, it has external and internal affects.

- Externally (no matter how it is defined) dependability is generally regarded by customers as a good thing. Certainly being late with delivery of goods and services can be a considerable irritation to customers. Especially with business customers, dependability is a particularly important criterion used to determine whether suppliers have their contracts renewed. So, again, the external affects of this performance objective are to increase the chances of customers returning with more business.

- Internally dependability has an affect on cost. There are three ways in which costs are affected – by saving time (and therefore money), by saving money directly, and by giving an organisation the stability which allows it to improve its efficiencies.

Flexibility

flexibility always means 'being able to change the operation in some way'. There are different forms of flexibility (product/service flexibility, mix flexibility, volume flexibility, and delivery flexibility). It is important to understand the difference between these different types of flexibility, but it is more important to understand the affect flexibility can have on the operation. There are external and internal affects of flexibility.

- Externally the different types of flexibility allow an operation to fit its products and services to its customers in some way. Mix flexibility allows an operation to produce a wide variety of

products and services for its customers to choose from. Product/service flexibility allows it develop new products and services incorporating new ideas which customers may find attractive. Volume and delivery flexibility allow the operation to adjust its output levels and its delivery procedures in order to cope with unexpected changes in how many products and services customers want, or when they want them, or where they want them.

- Once again, there are several internal effects associated with this performance objective. namely flexibility speeds up response, flexibility saves time (and therefore money), and flexibility helps maintain dependability.

Cost

The cost structure of different organisations can vary greatly. All the other four performance objectives contribute, internally, to reducing cost. This has been one of the major revelations within operations management over the last twenty years.If managed properly, high quality, high speed, high dependability and high flexibility can not only bring their own external rewards, they can also save the operation cost.

Review questions

1. Define the term operations management
2. Outline the main objectives of operations management
3. Explain the function of each of the three levels of management
4. Distinguish between service and manufacturing operations
5. Outline five stakeholders of an organization

References

Slack, N. and Lewis, M. (2011) *Operations Strategy*, 3rd edn, Pearson Education Limited, Harlow.

Suri, R. (2010) It's *About Time: The Competitive Advantage of Quick Response Manufacturing*, Productivity Press, New York.

Vonderembse, M.A. and White, G.P. (2004) *Core Concepts of Operations Management*, John Wiley and Sons Ltd., Chichester.

PRODUCT DESIGN PROCESS AND PRODUCTION PROCESS CHOICE

Objectives:

By the end of the chapter the student should be able to:

(i) Outline the product development process
(ii) Explain four production processes
(iii) Outline the contribution of purchasing to product development
(iv) Relate operation to demand and supply networks

Product design process

New product designs can provide a competitive edge by bringing new ideas to the market quickly, doing a better job of satisfying customer needs, or being easier to manufacture, use and repair. The product design process involves the steps of:

(i) generating ideas
(ii) product screening
(iii) preliminary design and
(iv) Final design.

(i) Generating Ideas

Ideas for new products and services should be sought from a variety of sources including market research, customer viewpoints, the organisation's research and development (R&D) department if one exists, competitors or relevant developments in new technology. Competitors can provide a good source of ideas and it is important that the organisation analyses any new products they introduce to the market and make an appropriate response. Reverse Engineering is a systematic approach to dismantling and inspecting a competitor's product to look for aspects of design that could be incorporated into the organisation's own product. This is especially prevalent when the product is a complex assembly such as a car, where design choices are myriad. Benchmarking compares a product against what is considered the best in that market segment and the making recommendations on how the product can be improved to meet that standard. Although a reactive strategy, benchmarking can be useful to organisation's who have lost ground to innovative competitors.

(ii) Product Screening

The screening process consists of market analysis, economic analysis and technical analysis.

(a)Market analysis: Market analysis consists of evaluating the product concept with potential customers through interviews, focus groups and other data collection methods. The physical product may be tested by supplying a sample for customer evaluation. The market analysis should identify whether sufficient demand for the proposed product exists and its it with the existing marketing strategy. At a strategic level the organisation can use the product life cycle to determine the likely cost and volume characteristics of the product. The product life cycle describes the product sales volume over time. In the early introduction phase production costs are high and design changes may be frequent. However there should be little or no competition for the new product and so a premium price can be charged to customers attracted to innovative products. The growth phase sees a rapid increase in volumes and the possibility of competitors entering the market. At this stage it is important to establish the product in the market as firmly as possible in order to secure future sales. Production costs should be declining as process improvements and standardisation takes place. In the mature phase competitive pressures will increase and it is important that sales are secured through a branded product to differentiate it from competitors and a

competitive price. There should be a continued effort at design improvement to both product and process. Some products, such as consumer durables, may stay in the mature phase almost indefinitely, and techniques such as advertising are used to maintain interest and market share

(b) Economic Analysis: Economic Analysis consists of developing estimates of production and demand costs and comparing them with estimates of demand. In order to perform the analysis requires an accurate estimate of demand as possible derived from statistical forecasts of industry sales and estimates of market share in the sector the product is competing in. These estimates will be based on a predicted price range for the product which is compatible with the position of the new product in the market. In order to assess the feasibility of the projected estimates of product costs in terms of such factors as materials, equipment and personnel must be estimated. Techniques such as cost/beneit analysis, decision theory and accounting measures such as net present value (NPV) and internal rate of return (IRR) may be used to calculate the profitability of a product. Another tool that can be used is the cost-volume-profit model that provides a simplified representation that can be used to estimate the profit level generated by a product at a certain product volume.

(c) Technical Analysis: Technical analysis consists of determining whether technical capability to manufacture the product. This covers such issues as ensuring materials are available to make the product to the specification required, and ensuring the appropriate machinery and skills are available to work with these materials. The technical analysis must take into account the target market and so product designers have to consider the costs of manufacturing and distributing the product in order to ensure it can be sold at a competitive price. Strategic analysis involves ensuring that the product provides a competitive edge for the organisation, drawing on its competitive strengths and is compatible with the core business

(iii) Preliminary Design

Product concepts that pass the feasibility stage enter preliminary design. The specification of the components of the package requires a product /service structure which describes the relationship between the components and a bill of materials or list of component quantities derived from the product structure. The process by which the package is created must also be specified in terms of mapping out the sequence of activities which are undertaken. This can be achieved with the aid of such devices as process low charts.

(iv) Final Design

The final design stage involves the use of a prototype to test the preliminary design until a final design can be chosen. Computer Aided Design (CAD) and Simulation Modelling can be used to construct a computer-based prototype of the product design.

Product design evaluation methods

The major product design evaluation methods are briefly explained below:

(i) CAD simulation models: Used to evaluate product design and its perceived use during the different stages of design process.

(ii) Checklists: used to define operations of a product/system and identify users' needs.

(iii) Interviewing users: in order identify users' needs and the ability of a product to meet them

(iv) Mock-up evaluation: involves evaluating product usage with users participation

(v) Motion studies: used to evaluate motion performances and identify critical conditions

Protocol analysis: involves evaluating a design, user's expertise level and understand users'

(vi) Concept of products.

(vii) Prototype evaluation: To verify a design outcome under real conditions.

(viii) Task-analysis: used to define and evaluate operational procedures of a human/product/system.

Methods for Improving Product Design

The following two methods are available that in improving the design process.

(i) Design for Manufacture (DFM): Although the ability of the product or service to fulfill customers needs is a major factor in design there is also a need to ensure that the product designed can be produced easily and at low cost. Design for Manufacture (DFM) is a concept which provides guidelines on how this can be achieved using techniques such as simpliication, standardisation and modularization. Simpliication involves a reduction in the number of components in the design in order to reduce cost and increase reliability. Standardisation involves using components that can be used in a number of products again reducing costs through economies of scale and minimising inventory. Modularisation means using modules or blocks of components that are standard across products. Again costs are reduced and reliability increased.

(ii) **Concurrent Engineering:** Concurrent engineering is when contributors to the design effort provide work throughout the design process as a team. This differs from the traditional design process when work is undertaken separately within functional areas such as engineering and operations. The problem with the traditional approach is the cost and time involved in bringing the product to market. In a traditional approach time is wasted when each stage in the design process waits for the previous stage to finish completely before it can commence and there may be a lack of communication between functional areas involved in the different stages of design. This can lead to an attitude of "throwing the design over the wall" without any consideration of problems that may be encountered by later stages. An example of this is decisions made at the preliminary design stage that adversely affect choices at the product build stage. This can cause the design to be repeatedly passed between departments to satisfy everyone's needs, increasing time and costs. By facilitating communication through the establishment of a project team problems of this type can be reduced.

Production Process Selection

When considering product design the issue of the design of the process that is used to produce that design should be considered also. The design of processes is different in all organisations and should be related to the volume and variety of the demand for the product in the market. In order to assist in selecting the appropriate process, process designs can be categorised under four process types:

(i) Project

(ii) Jobbing

(iii) Batch

(iv) Mass

(v) Continuous

A description of each process type is followed by some examples of where each process type might be used.

Project: Processes that produce products of high variety and low volume are termed projects. Project processes are used to make a one-of product to a customer specification. Normally transforming resources such as staff and equipment

that make the product must move or be moved to the location of the product. Other characteristics of projects are that they may require the coordination of many individuals and activities, demand a problem-solving approach to ensure they are completed on time and have a comparatively long duration of manufacture. The timescale of the completion of the project is an important performance measure. Because each project is unique it is likely that transforming resources will comprise general purpose equipment which can be used on a number of projects. Examples of the use of a project process include building construction, interior design and custom-built furniture.

Jobbing: Jobbing processes are used to make a one-of or low volume product to a customer specification. A feature of a jobbing process is that the product moves to the location of transforming resources such as equipment. Thus resources such as staff and equipment can be shared between many products. Other characteristics of jobbing processes are the use of skilled labour in order to cope with the need for customisation (i.e. variety) and the use of general purpose equipment which is shared between the products. There tends to be low utilisation of equipment in jobbing processes due to the need to undertake frequent setting up of the machinery when moving from processing one product to another. Examples of the use of a jobbing process include bespoke tailors and precision engineers.

Batch: Processes that produce products of medium variety and medium volume are termed batch which denotes that the products are grouped as they move through the design process. In a batch process the product moves to the location of transforming resources such as equipment and so resources are shared between the batches. Instead of setting up machinery between each product, as in a jobbing process, setups occur between batches, leading to a higher utilisation of equipment. Because of the relatively high volumes involved in batch it can be cost-effective to use specialised labour and equipment dedicated to certain product batches. A feature of batch processes is that, because it is difficult to predict when a batch of work will arrive at a machine, a lack of coordination can lead to many products waiting for that machine at any one time. These queues of work may dramatically increase the time the product takes to progress through the process. Examples of the use of a batch process include book printing, university classes and clothing manufacture.

Line: Processes that produce products of high volume and low variety are termed line or mass processes. Although there may be variants within the product design the production process will essentially be the same for all the products. Because of the high volumes of product it is cost effective to use specialised labour and equipment. A feature of line processes is that the movement of the product may be automated using a conveyor system and the production process broken down into a number of small, simple tasks. In order to ensure a smooth low of product the process times per unit must be equalised at each stage of production using a technique called line balancing. Because of the low product variety, setting up of equipment is minimised and utilisation of equipment is high. Examples of the use of a mass process include cars, consumer durables. etc

Continuous :Processes that operate continually to produce a very high volume of a standard product are termed continuous. he products produced by a continuous operation are usually a continuous low such as oil and gas. Continuous processes use a large amount of equipment specialised and dedicated to producing a single product (such as an oil refinery for example). To make this large investment in dedicated equipment cost effective continuous processes are often in constant operation, 24 hours a day. The role of labour in the operation of the processes is mainly one of monitoring and control of the process equipment with little contact with the product itself. Examples of a continuous process include water treatment plants, electricity production and steel making.

Environmentally friendly product design

These is a product design approach which focuses on designing a product in a manner that does not harm the environment and if possible is beneficial to the environment

Objectives of environmentally friendly product design

i. Compatible with the concept of a recycling society and with business sustainability.
ii. Reducing impacts on the global environment.
iii. Ensuring the safety of users and the protection of the environment.
iv. Improving functions and performance of products and reducing their environmental impacts.
v. Reduction of environmental pollutants.
vi. Resource saving and energy saving.
vii. Sustainable use of natural resources.
viii. Use of recycled resources (promoting the 4Rs).
ix. Simplified waste treatment and disposal. Emphasis on safety-consciousness. Environmental and safety information included on product labels

Guidelines for environmentally friendly product design

i. Design life cycles rather than products: All material inputs and energy use of a product during its whole life cycle should be considered
ii. Minimize the energy consumption of a product.
iii. Increase product life time: A product should be made more durable from a technical point of view, or making it upgradeable
iv. Do not design products, but services: People do not always want a product. They want a solution for a certain problem. A service rather than a product can be the right solution.
v. Use a minimum amount of material: Often the amount of material can be reduced critically looking at dimensions, required strength and production techniques.
vi. Use recycled materials: recycled materials must be used as much as possible. If there is a demand for recycled materials the supply will follow certainly.
vii. Make recyclable products: Only products that are disassembled easily and have a high enough yield will be chosen for recycling.

Contributions Of Purchasing And Supply In Design Of Product And Services

Market globalization and the rapid advancement of technologies require that companies differentiate themselves with innovative products and services to create competitive advantage. Increasingly, manufacturers face shortened product life cycles and increased pressure to shorten their time to market. These factors, in conjunction with the reality that companies are increasing their reliance on outsourcing necessitate that organizations involve suppliers in the new product development process. The effective integration of suppliers into the product value / supply chain will be a key factor for manufacturers in achieving the improvements necessary to remain competitive. Moreover, because purchasing specialists are usually a key liaison between the supplier and the buyer, an investigation of

their role in the new product design and development process is worthwhile. The purchasing function plays the following roles in product development:

(i) Coordinating role: If the project is of a more complex kind, for instance new technologies or materials are involved, the project purchaser gets a coordinating role. The prime mission for the project purchaser is then to work as link between the product development team and different purchasing specialists or suppliers.

(ii) Developing product specification: contributing to the development of the actual product by communicating criteria, norms and (im)possibilities regarding the development of new products (materials, components, assemblies) by suppliers. Some of these activities may be carried out by suppliers themselves.

(iii) Operation role: includes tasks like the planning and co-ordination of development activities of suppliers during a development project; preparing and starting such a development project is regarded as a preparation responsibility

(iv) Structure role: includes the permanent tasks related to the management of a base of preferred development suppliers

(v) Policy role: regards the formulation and communication of guidelines and policies regarding the role and tasks of the different departments and suppliers in product development, and the determination of develop-or-buy strategies.

Benefits of involving the purchasing function in product design

(i) Reduced costs due to reduced product costs and development costs

(ii) increased product performance due to high quality inputs procured by purchasing department

(iii) reduced development time due to continued availability of inputs as procured by the purchasing department

(iv) risks related to delivery are reduced due to the certainity guaranteed b the purchasing department's provision of inputs when required

Operations as a part of demand and supply networks

All businesses are both customers for some other businesses products and services and suppliers of products and services to their own customers (often businesses themselves). It would be extremely limited therefore to think about an operation in isolation. All operations are part of an interconnected network of, not only their own customers and suppliers, but their customers' customers and suppliers' suppliers. A supply network, is the collection of suppliers and customers with which the operation deals directly, and the total supply network, which includes customers' customers and suppliers' suppliers. In fact, no doubt second tier suppliers have third tier suppliers who are supplied by fourth

tier suppliers and so on. Similarly, there may well be further tiers of customers. A supply network is a pattern of temporal and spatial processes carried out at facility nodes and over distribution links, which adds value for customers through the manufacturing and delivery of products. It comprises the general state of business affairs in which all kinds of material (work-in-process material as well as finished products) are transformed and moved between various value-added points to maximize the value added for customers. It can also be referred to as a supply chain. The evolution of today's multi-tiered supply and demand networks is driven by the need to reduce costs and achieve long-term competitive advantage. The focus of this benchmark report is to identify key process and technology strategies that organizations need to adopt to regain control and visibility of their multi-enterprise supply chain networks.

The advantages of thinking about how operations fit into the total supply network are long term and strategic. They are,

i. It helps a company to understand how it can compete.
ii. It helps to identify the particularly significant relationships in the network.
iii. It helps a company to focus on long-term issues.
iv. It helps a company to identify cost reduction opportunities.

A fundamental and critical aspect of operations in the modern world is that of formulating, analyzing, and managing supply chains. Hence, in order to fully comprehend the scope of operations and operations management and to be able to advance theory and practice, we must consider supply chains. It is also important to emphasize the synergies between practice and the development of theory in operations management and in supply chain management. Operations management, typically, focuses on improving processes within an organization, whereas supply chain management uses and advances theory, tools, and practice for operations across organizations. Of course, many of the methodologies of relevance and application in operations management can be transferred to supply chain management.

The reality of supply chain networks today includes not only competition but also cooperation since decision-makers in the supply chains must interact not only in terms of the product flows but also in terms of pricing in order to satisfy the consumers. At the same time, decision-makers in supply chains are characterized by their individualized objectives, which may include not only profit maximization, but also risk minimization, as well as the incorporation of environmentally conscious objectives, to various degrees. The concept of supply chain networks is as applicable to services as it is to goods.

Characteristics of supply and demand networks

(i) Large-scale nature and complexity of network topology.
(ii) Congestion, which leads to nonlinearities.
(iii) Alternative behavior of users of the networks, which may lead to paradoxical phenomena.
(iv) Possibly conflicting criteria associated with optimization.
(v) Interactions among the underlying networks themselves, such as the Internet with electric power, financial, and transportation and logistical networks.

(vi) Recognition of their fragility and vulnerability.
(vii) Policies surrounding networks today may have major impacts not only economically, but also socially, politically, and security-wise.

Review questions

(1) Outline the steps involved in product design
(2) Explain four production methods which maybe utilized by a manufacturing entity
(3) Highlight the characteristics of environmentally friendly product design
(4) Outline the characteristics of supply and demand networks
(5) Discuss the contribution of purchasing in the product design process

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FACILITY LOCATION AND LAYOUT

Objectives:

By the end of the chapter the student should be able to:

(1) Define the term facility location
(2) Explain the factors influencing facility location
(3) Define the term facility layout
(4) Outline the principles of facilities layout
(5) Define the term work measurement

Facility Location

The organisation's strategy will need to address the issue of facility location. this must be considered in terms of the need to serve customer markets effectively and to meet long-range demand forecasts. the issues can be considered in terms of the competition and cost of the location decision and the size of the facility. A company's competitiveness will be affected by its locations as it will impact on costs such as for transportation and labour. In service operations when the facility may not only produce the good but also deliver it to the customer from the facility, the convenience of the location for the customer is vital. A location decision is costly and time consuming to change. the costs include the purchase of land and construction of buildings. An organisation may be located inappropriately due to a previous poor location decision and an unwillingness to face the costs of a subsequent relocation. A change in input costs, such as materials or labour, may also lead to a need to change location. Finally in order to meet the long-term demand forecast it is necessary to consider the size of the facility. Within a medium term planning cycle the size of the facility will impose an upper limit on the organisation's capacity. Purchasing additional components from suppliers or sub-contracting work can however increase this level. However these strategies may lead to higher costs and thus a loss of competitiveness. The ability to supplement capacity is most restricted in service operations when contact with the customer is required.

Location Factors

Many factors affect the location decision including the following:

(i) **Proximity to Customers:** For many service organisations in particular the location of the facility must be convenient for the potential customer. This can range from restaurants were customers may be prepared to travel a short distance to hospitals were the speed of response is vital to the service. High transportation costs for heavy or bulky materials may also lead to locating close to the customer.

(ii) **Proximity to suppliers:** The volume and bulk of the raw material involved in operations such as steel production means that a location decision will tend to favour areas near to suppliers. A manufacturer and seller of custom-built furniture however will need to be near potential customers. For service companies such as supermarkets and restaurants the need to be in a market-oriented locations means that the cost of transportation of goods will not be a major factor in the location decision. Distribution across country borders means that a whole series of additional costs and delays must be taken into account, including import duties and delays in moving freight between different transportation methods. A site near to an airport or a rail link to an airport may be an important factor if delivery speed is important.

(iii) **Proximity to labour:** Labour costs have generally become less important as the proportion of direct labour cost in high volume manufacturing have fallen. What is becoming more important is the skills and flexibility of the labour force to adapt to new working methods and to engage in continuous improvement efforts. The wage rate of labour can be a factor in location decisions, especially when the service can be provided easily in alternative locations. Information Technology companies involved in data entry can locate in alternative countries without the customer being aware.

(iv) **Government policy:** Regulatory policies on location of enterprises may at times limit the option available for the location of a firm. Such laws would include zoning laws which set out the types of businesses to be set out in different areas

(v) **Availability of the necessary infrastructure:** A firm is limited to establishing its operations in location with suitable infrastructure. A shipping company will not establish its

operations far away from the port.

Layout Design

Layout design concerns the physical placement of resources such as equipment and storage facilities. Layout design is important because it can have a significant effect on the cost and efficiency of an operation and can entail substantial investment in time and money. In many operations the installation of a new layout, or redesign of an existing layout, can be difficult to alter once implemented due to the significant investment required on items such as equipment. There are four basic layout types of:

(i) Process layout

(ii) Product layout

(iii) hybrid layout

(iv) Fixed-position layout

The above layout Types are discussed below:

Process layout: A process layout is one in which resources (such as equipment and people) which have similar processes or functions are grouped together. Process layouts are used when there is a large variety in the products or services being delivered and it may not be feasible to dedicate facilities to each individual product or service. A process layout allows the products or customers to move to each group of resources in turn, based on their individual requirements. Because of their flexibility process layouts are widely used. One advantage is that in service systems they allow a wide variety of routes that may be chosen by customers depending on their needs. Another advantage is that the product or service range may be extended and as long as no new resources are required may be accommodated within the current layout.

Product Layout: Product layouts, also termed line layouts, arrange the resources required for a product or service around the needs of that product or service. In manufacturing applications such as assembly lines with a high volume of a standard product the products will move in a low from one processing station to the next. In contrast to the process layout in which products move to the resources, here the resources are arranged and dedicated to a particular product or service.t he term product layout refers to the arrangement of the resources around the product or service. In services the requirements of a specific group of customers are identified and resources setup sequentially so the customers flow through the system, moving from one stage to another until the service is complete.

Hybrid Layout: A hybrid layout attempts to combine the efficiency of a product layout with the flexibility of a process layout. Hybrid layouts are created from placing together resources which service a subset of the total range of products or services. When grouping products or services together in this way the grouping is termed a family. the process of grouping the products or services to create a family is termed group technology.

Group technology has three aspects:

1. Grouping parts into families; Grouping parts or customers into families has the objective of reducing the changeover time between batches, allowing smaller batch sizes, and thus improving flexibility. Parts family formation is based on the idea of grouping parts or customers together according to factors such as processing similarity.
2. Group physical facilities into cells to reduce transportation time between processes; Physical facilities are grouped into cells with the intention of reducing material or customer movements. Whereas a process layout involves extensive movement of materials or customers between departments with common processes, a cell comprises all the facilities required to manufacture a family of components or delivery a service. Material and customer movement is therefore restricted to within the cell and throughput times are therefore reduced. Cells can be U-shaped to allow workers to work at more than one process whilst minimising movement.
3. Creating groups of multi-skilled workers; Creating groups of multi-skilled workers enables increased autonomy and flexibility on the part of operators. This enables easier changeovers from one part to another and increases the job enrichment of members of the group. This in turn can improve motivation and have a beneficial effect on quality.

Creating cells with dedicated resources can significantly reduce the time it takes for products and services to pass through the process by reducing queuing time. It also offers the opportunity for automation due to the close proximity of the process stages. Thus process technology can be used to replace a number of general purpose resources with a single dedicated multi-functional system such as a Flexible Manufacturing System. A disadvantage of hybrid layouts can be the extra expenditure due to the extra resources required in creating cells.Examples of hybrid layouts include custom manufacture, maternity unit in a hospital, cafeteria with multiple serving areas. In services a cell layout could involve an insurance organisation organised by type of claim (e.g. car, home, travel).

Fixed-Position layout: this layout design is used when the product or service cannot be moved and so the transforming process must take place at the location of product creation or service delivery. In a fixed position layout all resources for producing the product, such as equipment and labour must move to the site of the product or service. The emphasis when using a fixed-position layout is on the scheduling and coordination of resources to ensure that they are available in the required amounts at the required time. For example on a construction site most activities are dependent on the completion of other activities and cannot be undertaken simultaneously. The space available on the site may also constrain the amount of work activity that can take place at any one time. This means detailed scheduling of resources is required to minimise delays. In a restaurant it is important that the order is taken and food delivered to the table at the appropriate time. Examples of fixed-position layouts include construction sites such as for buildings or for large ships, aircraft manufacture and full service restaurants.

Review questions

1. Define the term facility location
2. Define the term facility
3. Outline five factors influencing facilty location decisions
4. Outline four types of organization layouts
5. Explain the three aspects of hybrid layout

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PRINCIPLES OF JOB DESIGN AND ERGONOMICS

Objectives

By the end of the chapter the student should be able to:

(i) Define the term job design

(ii) Define the term ergonomics

(iii) Outline the components of work study

(iv) Explain the principles of ergonomics

Job design

There are clearly many alternative designs for any given job. For this reason, an understanding of what the job design is supposed to achieve is particularly important. As before, the five performance objectives give us a guide to what is relevant in job design decisions.

1. Quality: The ability of staff to produce high-quality products and services can be affected by job design. This includes avoiding errors in the short term, but also includes designing jobs which encourage staff to improve the job itself in such a way as to make errors less likely.
2. Speed:Sometimes speed of response is the dominant objective to be achieved in job design. For example, the way in which the jobs of emergency service personnel are organised (the range of tasks for which they are trained, the sequence of activities in their approved procedures, the autonomy which they have to decide on appropriate action, and so on) will go a long way to determine their ability to respond promptly to emergencies and perhaps save lives.
3. Dependability: Dependable supply of goods and services is usually influenced, in some way, by job design. For example, in the postal services' working arrangements, multi-skilling, accurate use of sorting equipment through good staff-machine interface design, and the 'design' of postal staff's clothing, can all aid dependable delivery of letters and parcels.
4. Flexibility: Job design can affect the ability of the operation to change the nature of its activities. New product or service flexibility, mix flexibility, volume flexibility and delivery flexibility are all dependent to some extent on job design. (See Chapter 2 for a full description of these different types of flexibility). For example, staff who have been trained in several tasks (multi-skilling) may find it easier to cope with a wide variety of models and new product or service introductions.
5. Cost: All the elements of job design described above will have an effect on the productivity, and therefore the cost, of the job. Productivity in this context means the ratio of output to labour input: for example, the number of customers served per hour or the number of products made per worker.

In addition, job design will influence two other particularly important objectives.

6. Health and safety: Whatever else a job design achieves, it must not endanger the well-being of the person who does the job, other staff of the operation, the customers who might be present in the operation, or those who use any products made by the operation.
7. Quality of working life: The design of any job should take into account its effect on job security, intrinsic interest, variety, opportunities for development, stress level and attitude of the person performing the job.

Behavioural approaches to job design

The title 'behavioural' approaches in clumsy but reasonably descriptive. This approach is the first so far to take the feelings and motivation of individual members of staff into account. Now the ideas of job rotation, job enlargement and job enrichment are well established in job design practice. Nevertheless it is important to understand that this approach still keeps the responsibility for designing jobs with operations management (or personnel management, or human resource management, etc.). It does not pass any responsibility or power to the people doing the jobs. In that sense it is not fundamentally different from earlier approaches to job design. Its motivation and objectives may be different but its practice is still very 'top-down'. The principles of job desgn are:

(i) **Empowerment:** The idea of empowerment, for the first time gives some responsibility for job design to the individuals who will perform the job. But, as the chapter discusses, the extent of autonomy can vary significantly. At its most limited autonomy can merely involve asking staff for their suggestions as to how jobs should be designed. At its maximum, only the broadest and most general of objectives are set by higher management and the whole nature of the job and its organisation is left to those who perform it. In between these two extremes there are any number of levels. In that sense 'empowerment' can mean almost anything. What many companies discovered is that empowerment 'did not relieve them of the task of job design'. It has been found to be very important to be clear in drawing the boundary between those aspects of the job which staff can directly control and those which management still reserve the right to define. So, for example, an operation might draw up a list of issues which it reserves the right to impose such as types of behaviour which are not acceptable (racist, sexist, etc.), safety practices (compulsory wearing of protective headgear etc.), timing (when the process must start and when shift changeovers occur, etc.), and so on. However, it may also define a list of specific job issues which staff can decide for themselves, sequencing of activities, scheduling of activities, appropriate work methods, and so on.

(ii) **Team-working and job design:** The significance of this influence on job design is that the 'unit of analysis' of job design changed. So, rather than automatically assume that job design involved defining the content of a job for each individual, a further variable was introduced – the team. A team is a group of individuals who, together, have a set of tasks to perform. From the point of view of the staff who form the team there may be a number of advantages in working on a team basis rather than an individual basis. The interest, motivation and fun which can be gained from working closely with colleagues can make any job more attractive. From the operations point of view several people working together can be not only more efficient and more flexible but also more creative in the way they seek solutions to continually improve their part of the operation.

(iii) **Flexible working:** Three types of flexible working are described in the chapter,

- skills flexibility
- time flexibility
- location flexibility.

In some ways this sequence of different types of flexibility is in order of difficulty. Skills flexibility involves individuals being able to do more than one job. This allows the operation to be more responsive as markets or other conditions change and also (arguably) makes jobs more interesting. It is not always easy to achieve skills flexibility, but at least most people are together in the operation at more or less the same time. Time flexibility, on the other hand, can present more difficulties because (by definition) not everyone will necessarily be together at the same time. Location flexibility can present even more problems, especially if individual members of staff rarely, if ever, meet up.

(iv) **Job Enlargement:** this involves the horizontal integration of tasks to expand the range of tasks involved in a particular job. If successfully implemented this can increase task identity, task significance and skill variety through involving the worker in the whole work task either individually or within the context of a group. Job Rotation is a common form of job enlargement and involves a worker changing job roles with another worker on a periodic basis. If successfully implemented this can help increase task identity, skill variety and autonomy through involvement in a wider range of work task with discretion about when these mix of tasks can be undertaken. However this method does not actually improve the design of the jobs and it can mean that people gravitate to the jobs that suit them and are not interested in initiating rotation with colleagues. At worst it can mean rotation between a number of boring jobs with no acquisition of new skills.

(v) **Job Enrichment:** Job enrichment involves the vertical integration of tasks and the integration of responsibility and decision making. If successfully implemented this can increase all five of the desirable job characteristics by involving the worker in a wider range of tasks and providing responsibility for the successful execution of these tasks. his technique does require feedback to so that the success of the work can be judged. he

managerial and staf responsibilities potentially given to an employee through enrichment can be seen as a form of empowerment. his should in turn lead to improved productivity and product quality.

Methods Analysis

Dividing and analysing a job is called method study. he approach takes a systematic approach to reducing waste, time and effort. the approach can be analysed in a six-step procedure:

1. Select: Tasks most suitable will probably be repetitive, require extensive labour input and be critical to overall performance.
2. Record: this involves observation and documentation of the correct method of performing the selected tasks. Flow process charts are often used to represent a sequence of events graphically. they are intended to highlight unnecessary material movements and unnecessary delay periods.
3. Examine: this involves examination of the current method, looking for ways in which tasks can be eliminated, combined, rearranged and simplified.t his can be achieved by looking at the low process chart for example and re-designing the sequence of tasks necessary to perform the activity.
4. Develop: Developing the best method and obtaining approval for this method. his means choosing the best alternative considered taking into account the constraints of the system such as the performance of the irm's equipment. he new method will require adequate documentation in order that procedures can be followed. Speciications may include tooling, operator skill level and working conditions.
5. Install: Implement the new method. Changes such as installation of new equipment and operator training will need to be undertaken.
6. Maintain: Routinely verify that the new method is being followed correctly

New methods may not be followed due to inadequate training or support. On the other hand people may ind ways to gradually improve the method over time. Learning curves can be used to analyse these efects.

Motion Study

Motion study is the study of the individual human motions that are used in a job task. The purpose of motion study is to try to ensure that the job does not include any unnecessary motion or movement by the worker and to select the sequence of motions that ensure that the job is being carried out in the most efficient manner possible. For even more detail videotapes can be used to study individual work motions in slow motion and analyse them to find improvement a technique termed micromotion analysis. The principles are generally categorised according to the efficient use of the human body efficient arrangement of the workplace and the efficient use of equipment and machinery. These principles can be summarised into general guidelines as follows:

- Efficient Use of the Human Body
  Work should be rhythmic, symmetrical and simplified. The full capabilities of the human body should be employed. Energy should be conserved by letting machines perform tasks when possible.
- Efficient Arrangement of the Workplace
  Tools, materials and controls should have a defined place and be located to minimise the motions needed to get to them. The workplace should be comfortable and healthy.
- Efficient use of Equipment
  Equipment and mechanised tools enhance worker abilities. Controls and foot-operated devices that can relieve the hand/arms of work should be maximised. Equipment should be constructed and arranged to it worker use.

Motion study is seen as one of the fundamental aspects of scientific management and indeed it was effective in the design of repetitive, simplified jobs with the task specialisation which was a feature of the mass production system. The use of motion study has declined as there has been a movement towards greater job responsibility and a wider range of tasks within

a job. However the technique is still a useful analysis tool and particularly in the service industries, can help improve process performance.

Work Measurement

The second element of work-study is work measurement which determines the length of time it will take to undertake a particular task. This is important not only to determine pay rates but also to ensure that each stage in a production line system is of an equal duration (i.e. 'balanced') thus ensuring maximum output. Usually the method study and work measurement activities are undertaken together to develop time as well as method standards. Setting time standards in a structured manner permits the use of benchmarks against which to measure a range of variables such as cost of the product and share of work between team members. However the work measurement technique has been criticised for being misused by management in determining worker compensation. The time needed to perform each work element can be determined by the use of historical data, work sampling or most usually time study.

Time Study

The purpose of Time Study is through the use of statistical techniques to arrive at a standard time for performing one cycle of a repetitive job. This is arrived at by observing a task a number of times.The standard time refers to the time allowed for the job under specific circumstances, taking into account allowances for rest and relaxation. The basic steps in a time study are indicated below:

1. Establish the standard job method: It is essential that the best method of undertaking the job is determined using method study before a time study is undertaken. If a better method for the job is found then the time study analysis will need to be repeated.
2. Break down the job into elements: The job should be broken down into a number of easily measurable tasks. This will permit a more accurate calculation of standard time as varying proficiencies at different parts of the whole job can be taken into account.
3. Study the job: this has traditionally been undertaken with a stopwatch, or electronic timer, by observation of the task. Each time element is recorded on an observation sheet. A Video camera can be used for observation, which permits study away from the workplace, and in slow motion which permits a higher degree of accuracy of measurement.
4. Rate the worker's performance: As the time study is being conducted a rating of the worker's performance is also taken in order to achieve a true time rating for the task. Rating factors are usually between 80% and 120% of normal. This is an important but subjective element in the procedure and is best done if the observer is familiar with the job itself.
5. Compute the average time: Once a sufficient sample of job cycles have been undertaken an average is taken of the observed times called the cycle time. The sample size can be determined statistically, but is often around five to fifteen due to cost restrictions.
6. Compute the normal time: Adjust the cycle time for the efficiency and speed of the worker who was observed. the normal time is calculated by multiplying the cycle time by the performance rating factors.
   Normal Time (NT) = cycle time (CT) x rating factor (RF)
7. Compute the standard time: The standard time is computed by adjusting the normal time by an allowance factor to take account of unavoidable delays such as machine breakdown and rest periods. The standard time is calculated as Standard Time (ST) = Normal Time (NT) x allowance

Predetermined Motion Times

One problem with time studies is that workers will not always co-operate with their use, especially if they know the results will be used to set wage rates. Combined with the costs of undertaking a time study, a company may use historical data in the form of time files to construct a new standard job time from previous job element .this has the disadvantage however of the reliability and applicability of old data. Another method for calculating standard times without a time study is to use

predetermined motion time system (PMTS) which provides generic times for standard micromotions such as reach, move and release which are common to many jobs. The standard item for the job is then constructed by breaking down the job into micromotions that can then be assigned a time from the motion time database. The standard time for the job is the sum of these micromotion times. Factors such as load weight for move operations are included in the time motion database.

Advantages of the predetermined motion times

(i) standard times can be developed for jobs before they are introduced to the workplace without causing disruption and needing worker compliance.

(ii) performance ratings are factored in to the motion times and so the subjective part of the study is eliminated.

(iii) The timings should also be much more consistent than historical data for instance.

Disadvantages of the predetermined motion times

(ii) the fact that these times ignore the context of the job in which they are undertaken

(iii) The timings are provided for the micromotion in isolation and not part of a range of movement.

(iv) The sample is from a broad range of workers in different industries with different skill levels, which may lead to an unrepresentative time.

(v) Also the timings are only available for simple repetitious work which is becoming less common in industry.

Work Sampling

Work Sampling is useful for analysing the increasing proportion of non-repetitive tasks that are performed in most jobs. It is a method for determining the proportion of time a worker or machine spends on various activities and as such can be very useful in job redesign and estimating levels of worker output. the basic steps in work sampling are indicated below:

1. Define the job activities: All possible activities must be categorised for a particular job. e.g. "worker idle" and "worker busy" states could be used to define all possible activities.
2. Determine the number of observations in the work sample: The accuracy of the proportion of time the worker is in a particular state is determined by the observation sample size. Assuming the sample is approximately normally distributed the sample size can be estimated using the following formula.

   $n = (z/e)^2 * p(1 - p)$

   where

   n = sample size

   z = number of standard deviation from the mean for the desired level of confidence e = the degree of allowable error in the sample estimate

   p = the estimated proportion of time spent on a work activity

The accuracy of the estimated proportion p is usually expressed in terms of an allowable degree of error e (e.g. for a 2% degree of error, e = 0.02). The degree of confidence would normally be 95% (giving a z value of 1.96) or 99% (giving a z value of 2.58).

3. Determine the length of the sampling period: There must be sufficient time in order for a random sample of the number of observations given by the equation in 2 to be collected. A random number generate can be used to generate the time between observations in order to achieve a random sample.
4. Conduct the work sampling study and record the observations: Calculate the sample and calculate the proportion (p) by dividing the number of observations for a particular activity by the total number of observations.

5. Periodically re-compute the sample size required: It may be that the actual proportion for an activity is different from the proportion used to calculate the sample size in step2. Therefore as sampling progresses it is useful to re-compute the sample size based on the proportions actually observed.

Ergonomics

Ergonomics can be defined simply as the study of work. More specifically, ergonomics is the science of designing the job to fit the worker, rather than physically forcing the worker's body to fit the job. Adapting tasks, work stations, tools, and equipment to fit the worker can help reduce physical stress on a worker's body and eliminate many potentially serious, disabling work- related musculoskeletal disorders (MSDs). Ergonomics draws on a number of scientific disciplines, including physiology, biomechanics, psychology, anthropometry, industrial hygiene, and kinesiology.

The Impact Of Ergonomics On Workplace Design

The goal of Ergonomics is to provide maximum productivity with minimal cost; in this context cost is expressed as the physiological or health cost to the worker. In a workplace setting there are seldom a large number of tasks that exceed the capabilities of most of the work force. There may be jobs that will include a specific task that requires extended reaches or overhead work that cannot be sustained for long periods, by using Ergonomic principles to design these tasks; more people should be able to perform the job without the risk of injury.

Matching the requirements of a job with the capabilities of the worker is the approach to be adopted in order to reduce the risks of musculoskeletal injuries resulting from handling materials manually. Proactive Ergonomics emphasises the prevention of work related musculoskeletal disorders through recognising, anticipating and reducing risk factors in the planning stages of new systems of work or workplaces. In effect, to design operations that ensures proper selection and use of tools, job methods, workstation layouts and materials that impose no undue stress and strain on the worker. Additional costs are incurred in redesigning or modifying work processes therefore it is more cost effective to reduce risk factors at the design stage. A proactive approach to Ergonomics will ensure that:

• Designers will receive training in ergonomics and have appropriate information and guidelines regarding risk reduction
• Decision-makers planning new work processes should have knowledge of Ergonomics principles that contribute to the reduction or elimination of risk.
• Design strategies emphasise fitting job demands to the capabilities and limitations of workers. For example, for tasks requiring heavy materials handling, use of mechanical assist devices to reduce the need for manual handling would be designed into the process
• Other aspects of design should be considered including load design, layout of the workplace to allow for ease of access when using mechanical aids and eliminating unnecessary lifting activities.

Responsibilities of managers in ergonomics

i. Implementing and maintaining ergonomic principles
ii. Ensuring that employees are properly trained in ergonomic principles
iii. Ensuring that employees follow safe ergonomic practices
iv. Actively practicing and developing positive attitudes towards ergonomic issues
v. Ensuring that employees use the ergonomic equipment provided
vi. Considering workplace layout, ergonomics and individual needs when allocating tasks to people in your area

Responsibilities of employees in ergonomics

i. Complying with ergonomic safety instructions of their organisation
ii. Not putting themselves or other at risk by their actions or omissions
iii. Making proper use of ergonomic equipment provided
iv. Using training received in applying ergonomic principles to their tasks
v. Reporting potential ergonomic hazards and problem to their Area OHS Supervisors

General principles of ergonomics

i. Correct, neutral posture: Maintain Postures where the body is aligned and balanced, while sitting or standing. The head is kept upright and is not turned to either side more than about 30 degrees or tilted forward or backward more than about 15 degrees. When the worker is standing, the torso is not bent more than 10 to 20 degrees from the vertical position and the natural curves of the spine are maintained. The pelvis and shoulders should face straight ahead to avoid twisting the torso. The shoulders are relaxed and knees slightly bent. The arms hang normally at the side, with elbows close to the body. The elbows are not bent more than about 90 degrees and the palms face in toward each other and the center line of the body. The wrists are in line with the forearms and are not bent sideways, forward (towards the palm), or backward (towards the back of the hand.) When the worker is seated, the buttocks and feet are firmly supported.

ii. Cleanliness and orderliness: Establishing a strong housekeeping program will keep the work place tidy and reduce the risk of tripping over cords and debris. It also extends the life of tools and equipment, and results in increased productivity.

iii. Lifting: Lifting properly is important. While there are some general lifting guidelines, a different approach may be needed for each load to be lifted. Sometimes it is appropriate to lift with the legs, and other times the back should be used to lift. These techniques depend on the size and shape of the load, and the frequency of lifting that is required.

iv. Planning: Planning should be done with ergonomics in mind. Items to be planned include determining routes between staging areas and work spaces, scheduling for members of other trades, and knowing what services and utilities will be provided.

v. Power zone: lifting should be done with the power zone. The power zone for lifting is close to the body, between mid-thigh and mid-chest height. This zone is where arms and back can lift the most with the least amount of effort.

vi. Proper handholds: Proper handholds make lifting easier and reduce the risk of injury. Handholds should be made large enough to accommodate larger hands and should not dig into fingers and palms.

vii. Pulling vs. Pushing: Pushing is generally preferable to pulling. Pushing allows the employee to use large muscle groups and apply more force to the load. Pulling carries a greater risk of strain and injury.

viii. Staging: Staging is an important step in any electrical project. Proper staging includes placing materials as close as possible to work spaces, and storing materials at ideal heights so employees can utilize the power zone to take materials from storage.

ix. Task Rotation: Many stressors cannot be engineered out of a task, short of complete automation. Rotation of assignments can be an effective means of limiting the amount of time employees are exposed to these stressors. This will often reduce the chance of injury, because the risk of injury is proportional to the amount of time one is exposed to a stressor.

Review questions

(1) Distinguish between work sampling and work measurement
(2) Outline five principles of ergonomics
(3) Explain the steps involved in time study
(4) Highlight the factors to be considered in effective job design
(5) Explain the concept of methods analysis

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INVENTORY MANAGEMENT

Objectives:

By the end of the chapter the student should be able to:

(1) Define the term inventory
(2) Explain the different types of inventory
(3) Distinguish between dependent and independent demand
(4) Calculate the EOQ
(5) Calculate the minimum stock level

Inventory

Inventory is a stock or store of goods. It includes raw materials or stock incoming suppliers.

Types of inventory

(i) Raw materials and purchased parts
(ii) Partially completed goods
(iii) Finished-goods inventories or merchandise
(iv) Replacement parts, tools, and suppliers
(v) Goods-in-transit to warehouses or Goods In progress

Types of Demand:

1) Dependent Demand

These are items that are typically subassemblies or component parts that will be used in the production of a final or finished product. Subassemblies and component a part is derived from the number of finished units that will be produced. Example: Demand for wheels for new cars.

2) Independent Demand

These are items that are the finished goods or other end items. These items are sold or at least shipped out rather than used in making another product.

Functions of Inventory

1. To meet anticipated customer demand. These inventories are referred to as anticipation stocks because they are held to satisfy planned or expected demand.

2. To smooth production requirements. Firms that experience seasonal patterns in demand often build up inventories during off-season to meet overly high requirements during certain seasonal periods. Companies that process fresh fruits and vegetable deal with seasonal inventories

3. To decouple operations. The buffers permit other operations to continue temporarily while the problem is resolved. Firms have used buffers of raw materials to insulate production from disruptions in deliveries from suppliers, and finished goods inventory to buffer sales operations from manufacturing disruptions.

4. To protect against stock-outs. Delayed deliveries and unexpected increases in demand increase the risk of shortages. The risk of shortages can be reduced by holding safety stocks, which are stocks in excess of anticipated demand.

5. To take advantage of order cycles. Inventory storage enables a firm to buy and produce in economic lot sizes without having to try to match purchases or production with demand requirements in short run.

6. To hedge against price increase. The ability to store extra goods also allows a firm to take advantage of price discounts for large orders.

To permit operations. Production operations take a certain amount of time means that there will generally be some work-in-process inventory.

Effects of inadequate inventory controls

Inadequate control of inventories can result into two categories of consequences:

1) Under stocking results in missed deliveries, lost sales, dissatisfied customers and production bottlenecks.

2) Overstocking unnecessarily ties up funds that might be more productive elsewhere

Objectives of Inventory Management

To achieve satisfactory levels of customer service while keeping inventory costs within reasonable bounds. Specifically Decision maker tries to achieve a balance in stocking and Fundamental decision must be made related to the timing and size of orders

Requirements for Effective Inventory Management

To be effective, management must have the following:

1. A system to keep track of the inventory on the hand on order.

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

3. Knowledge of lead times and lead time variability.

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

5. A classification system for inventory items.

Stock taking systems

1) Periodic System

This is a physical count of items in inventory is made at periodic intervals (e.g. weekly, monthly) in order to decide how much to order of each item. Major users: Supermarkets, discounts stores, and department stores.

Advantage

Orders for many items occur at the same time, which can result in economies in processing and shipping orders

Disadvantages

a) Lack of control between reviews.

b) The need to protect against shortages between review periods by carrying extra stock.

c) The need to make a decision on order quantities at each review

2) Perpetual Inventory System (also known as a continual system)

This keeps track of removals from inventory on a continuous basis, so the system can provide information on the current level of inventory for each item.

Advantages

1. The control provided by the continuous monitoring of inventory withdrawals.
2. The fixed-order quantity; management can identify an economic order size.

Disadvantage

2. The added cost of record keeping.

3) Two-bin-system method

Is two containers of inventory; reorder when the first is empty. The advantage of this system is that there is no need to record each withdrawal from inventory; the disadvantage is that the reorder card may not be turned in for a variety of reasons.

4) Tracking System

Universal Product Code (UPC) bar code printed on a label that has information about the item to which it is attached. Bar coding represents an important development for other sectors of business besides retailing. In manufacturing, bar codes attached to parts, subassemblies, and finished goods greatly facilitate counting and monitoring activities.

Demand Forecast and Lead time Information

Managers need to know the extent to which demand and lead time might vary; the greater the potential variability, the greater the need for additional stock to reduce the risk of a shortage between deliveries.

Inventory Cost

1. **Holding or Carrying Cost** is the costs to carry an item in inventory for a length of time usually a year. Cost includes interest, insurance, taxes, depreciation, obsolescence, deterioration, spoilage, pilferage, breakage, etc.
2. **Ordering Cost** is cost of ordering and receiving inventory. These include determining how much is needed, preparing invoices, inspecting goods upon arrival for quality and quantity, and moving the goods to temporary storage.
3. **Storage Cost** is cost resulting when demand exceeds the supply of inventory on hand. These

costs can include the opportunity cost of not making a sale, loss of customer goodwill, late charges, and similar costs

Inventory Decisions

The main concern of inventory management is the trade-off between the cost of not having an item in stock against the cost of holding and ordering the inventory. A stock-out can either be to an internal customer in which case a loss of production output may occur, or to an external customer when a drop in customer service level will result. In order to achieve a balance between inventory availability and cost the following inventory management aspects must be addressed of volume - how much to order and timing - when to order.

The Economic Order Quantity (EOQ) Model

The Economic Order Quantity (EOQ) calculates the inventory order volume which minimises the sum of the annual costs of holding inventory and the annual costs of ordering inventory. The model makes a number of assumptions including:

- Stable or Constant Demand
- Fixed and identifiable ordering cost
- The cost of holding inventory varies in a linear fashion to the number of items held
- The item cost does not vary with the order size
- Delivery lead time does not vary
- No quantity discounts are available
- Annual demand exists

These assumptions have led to criticisms of the use of EOQ in practice. The assumption of one delivery per order, and then the use of that stock over time increases inventory levels and goes against a JIT approach. Also annual demand will not exist for products with a life-cycle of less than a year. However, the EOQ approach still has a role in inventory management in the right circumstances and if its limitations are recognised.

Using the EOQ each order is assumed to be of Q units and is withdrawn at a constant rate over time until the quantity in stock is just sufficient to satisfy the demand during the order lead time (the time between placing an order and receiving the delivery). At this time an order for Q units is placed with the supplier. Assuming that the usage rate and lead time are constant the order will arrive when the stock level is at zero, thus eliminating excess stock or stock-outs.

The order quantity must be set at a level which is not too small, leading to many orders and thus high order costs and not too large leading to high average levels of inventory and thus high holding costs.

The annual holding cost is the average number of items in stock multiplied by the cost to hold an item for a year. If the amount in stock decreases at a constant rate from Q to 0 then the average in stock is Q/2. Thus if C_H is the average annual holding cost per unit, the total annual holding cost is:

$$\text{Annual Holding Cost} = \frac{Q}{2} * C_H$$

The annual ordering cost is a function of the number of orders per year and the ordering cost per order. If D is the annual demand, then the number of orders per year is given by D/Q. Thus if C_O is the ordering cost per order then the total annual ordering cost is:

$$\text{Annual Ordering Cost} = \frac{D}{Q} * C_O$$

Thus the total annual inventory cost is the sum of the total annual holding cost and the total annual ordering cost: Total

$$\text{Annual Cost} = \frac{Q}{2} * C_H + \frac{D}{Q} * C_O$$

Where

Q = order quantity

CH = holding cost per unit

D = annual demand

Co = ordering cost per order

The minimum total cost point is when the holding cost is equal to the ordering cost and solving for Q gives:

$$EOQ = \sqrt{\frac{2DCo}{CH}}$$

Example:

SaveMart needs 1000 coffee makers per year. The cost of each coffee maker is ksh78. Ordering cost is ksh100 per order. Carrying cost is 40% of per unit cost. Lead time is 5 days. SaveMart is open 365 days/yr.

Required

Calculate:

(i) The EOQ

(ii) The annual ordering cost

(iii) The annual stock holding cost

(iv) The total cost associated with the EOQ

$$EOQ = \sqrt{\frac{2DCo}{CH}} = \sqrt{\frac{2*1000*100}{0.4*78}} = 80 \text{ units}$$

$$\text{Annual ordering cost} = \frac{D*Co}{EOQ} = \frac{1000*100}{80} = 1250$$

$$\text{Annual stock holding cost} = \frac{EOQ*CH}{2} = \frac{80*31.2}{2} = 1248$$

Total cost =annual ordering cost + annual stock holding cost=1250+1248=2498

The Re-Order Point (ROP) Model

The EOQ model tells us how much to order, but not when to order. The Reorder point model identfiies the time to order when the stock level drops to a predetermined amount. This amount will usually include a quantity of stock to cover for the delay between order and delivery (the delivery lead time) and an element of stock to reduce the risk of running out of stock when levels are low (the safety stock).

The previous economic order quantity model provides a batch size that is then depleted and replenished in a continuous cycle within the organisation. Thus the EOQ in effect provides a batch size which the organisation can work to. However this assumes that demand rates and delivery times are fixed so that the stock can be replenished at the exact time stocks are exhausted. Realistically though both the demand rate for the product and the delivery lead-time will vary and thus the risk of a stock-out is high. The cost of not having a item in stock when the customer requests it can obviously be costly both in terms of the potential loss of sales and the loss of customer goodwill leading to further loss of business.

Safety Stock and Service Level

Safety stock is used in order to prevent a stock-out occurring. It provides an extra level of inventory above that needed to meet predicted demand, to cope with variations in demand over a time period. he level of safety stock used, if any, will vary for each inventory cycle, but an average stock level above that needed to meet demand will be calculated.To calculate the safety stock level a number of factors should be taken into account including:

- cost due to stock-out
- cost of holding safety stock
- variability in rate of demand
- variability in delivery lead time

It is important to note that there is no stock-out risk between the maximum inventory level and the reorder level. The risk occurs due to variability in the rate of demand and due to variability in the delivery lead time between the reorder point and zero stock level.

The reorder level can of course be estimated by a rule of thumb, such as when stocks are at twice the expected level of demand during the delivery lead time. However to consider the probability of stock-out, cost of inventory and cost of stock-out the idea of a service level is used. The service level is a measure of the level of service, or how sure, the organisation is that it can supply inventory from stock. T his can be expressed as the probability that the inventory on hand during the lead time is sufficient to meet expected demand (e.g. a service level of 90% means that there is a 0.90 probability that demand will be met during the lead time period, and the probability that a stock-out will occur is 10%. the service level set is dependent on a number of factors such as stockholding costs for the extra safety stock and the loss of sales if demand cannot be met.

The ABC Inventory Classification System

Normally a mix of fixed-order-interval and fixed order quantity inventory systems are used within an organisation. When there are many inventory items involved this raises the issue of deciding which particular inventory system should be used for a particular item. The ABC classification system sorts inventory items into groups depending on the amount of annual expenditure they incur. This will depend on both the estimated number of items used annually multiplied by the unit cost. To instigate an ABC system a table is produced listing the items in expenditure order (with largest expenditure at the top), and showing the percentage of total expenditure and cumulative percentage of the total expenditure for each item.

By reading the cumulative percentage figure it is usually found, following Pareto's Law, that 10-20% of the items account for 60-80% of annual expenditure. T hese items are called A items and need to be controlled closely to reduce overall expenditure. This often implies a Fixed quantity system with perpetual inventory checks or a fixed-interval system employing a small time interval between review periods. It may also require a more strategic approach to management of these items which may translate into closer buyer-supplier relationships. The B items account for the next 20-30% of

items and usually account for a similar percentage of total expenditure. These items require fewer inventory level reviews than A items. A fixed order interval system with a minimum order level may be appropriate here. Finally C items represent the remaining 50-70% of items but only account for less than 25% of total expenditure. Here much less rigorous inventory control methods can be used, as the cost of inventory tracking will outweigh the cost of holding additional stock.

It is important to recognise that overall expenditure may not be the only appropriate basis on which to classify items. Other factors include the importance of a component part on the overall product, the variability in delivery time, the loss of value through deterioration and the disruption caused to the production process if a stock-out occurs.

Review questions

1. Define the term inventory
2. List the types of inventory that may be held by an organization
3. Explain the ABC stock classification system
4. Discuss the reorder point model
5. List five assumptions of the EOQ model

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ASSET MAINTENANCE AND MANAGEMENT
Objectives;
By the end of the chapter the student should be able to:

(i) Define the term asset management
(ii) Highlight the objectives of asset management
(iii) Outline the components of an asset management plan
(iv) Describe the approaches to asset maintenance

Asset management

Asset management, broadly defined, refers to any system that monitors and maintains things of value to an entity or group. It may apply to both tangible assets such as buildings and to intangible concepts such as intellectual property and goodwill. Asset management is a systematic process of operating, maintaining, upgrading, and disposing of assets cost-effectively. Alternative views of asset management in the engineering environment are: the practice of managing assets to achieve the greatest return (particularly useful for productive assets such as plant and equipment), and the process of monitoring and maintaining facilities systems, with the objective of providing the best possible service to users (appropriate for public infrastructure assets). Civilization has always relied on its technological assets to support key functions like transport, public health, business, and commerce. There is a clear link between the provision and sophistication of technological assets and our modern lifestyle. Romans built a strong empire through their construction of roads, aqueducts and other assets.

Objectives of asset management

(i) Identify, develop or enhance business processes that cut across all business units
(ii) Identify the critical business areas that will create value and illustrate the probability of success.
(iii) Provide effective monitoring capabilities which allow decision makers to manage identified opportunities
(iv) Prevent value destruction by stabilizing and positioning the organization for integration and implementation

Asset management plan

An Asset Management Plan (AMP) is a tactical plan for managing an organisation's infrastructure and other assets to deliver an agreed standard of service. Typically, an Asset Management Plan will cover more than a single asset, taking a system approach - especially where a number of assets are co-dependent and are required to work together to deliver an agreed standard of service. The International Infrastructure Management Manual defines an Asset Management Plan as; "a plan developed for the management of one or more infrastructure assets that combines multi-disciplinary management techniques (including technical & financial) over the life cycle of the asset in the most cost effective manner to provide a specific level of service.

Components of an asset management system

An AMP typically covers the following areas:

1. Asset System Description
2. Standard of Service Definition
3. Current Asset Performance
4. Planned Actions
5. Costs
6. Benefits
7. Potential Improvements

Asset system description: Description of the problem that the asset system aims to reduce. What assets are currently employed to address the problem? Essentially, why do these assets exist? What would occur if these assets didn't exist. Identify dependencies between different parts of the asset system. This is important to understand why the assets are there in the first place.

Standard of service definition: How should the above assets be performing and to what condition? Define the Standard of Service (SoS) for the various parts of the asset system or group (a simple performance specification). Describe how the system, as a whole, is intended to perform in a measurable way. Usually consists of two parts, a measurable performance specification, and a minimum condition grade (CG). The minimum CG should take account of the potential consequences of failure i.e. a flood defence protecting an urban area that would flood to a depth of 1m should the wall fail under design conditions should have a higher minimum CG (2 or 3). An earth embankment that is only protecting agricultural land, where the consequences of failure are significantly less will likely have a lower minimum CG (4 or 5)

Current asset performance: What condition are the assets currently in? List/Inventory & Condition of all "assets" within the system, with their unique identifiers. This could include information such as asset owner, age, estimate of remaining life etc. This is important to understand what state the assets are currently in.

Planned actions and lifecycle management: A short narrative explaining the near-term actions required to bridge the gap between where we are, and where we want to be. In the case where we are already at or above the agreed SoS, this section explains how we will continue to do so for the least cost - enabling an innovative approach to providing the agreed SoS. This is important to understand what actions are planned to bring or keep the assets above their minimum condition, and able to perform their intended function.

Costs: What are the short, medium and longer-term costs for the asset system? A forward looking cost-profile for operating, maintaining, refurbishing and replacing to sustain the Standard of Service. Ideally the cost-profile will extend to cover the life of the longest-lived asset in the system, so as to estimate the whole-life cost, and make it possible to determine the average annual costs.This section may need to be revisited and updated annually, and may form the basis for an annual bid for funding. This is important to understand what the planned actions are going to cost, as well as the ongoing "management" and overheads directly related to this particular asset system. Also essential from a local perspective, is optimizing the approach to providing the SoS.

Benefits: Focuses on why the need to sustain the agreed standard of service of the assets in the asset system. Without exception, assets should provide some measure of benefits that can be measured or explained. This will usually involve the translation of the standard of service into a monetary figure. Other benefits may be social or environmental, which may be difficult to quantify in monetary or quantitative terms, but some attempt to record all the relevant benefits is important, and more qualitative means may be employed.

Improvements: Potential improvements to the Standard of Service: The standard of service currently delivered may be improved by acquisition, enhancement or other means. An "improvement" may also include the potential to reduce the standard of service, and potentially even dispose or divest of an asset or assets in an asset system. These improvements represents a potential change to the standard of service and is typically managed as a project, complete with some form of appraisal of the additional expenditure, comparing different options and selecting a preferred options based on whatever decision process is appropriate. The development and justification of a change project is outside the scope of an Asset Management Plan.

Asset maintenance

Asset Maintenance is a method where the assets are maintained at a level that minimizes operating cost while delivering the desired service of the asset throughout its life cycle. The benefits of asset maintenance include:

(i) Asset performance is optimized
(ii) Minimize costs from unplanned maintenance
(iii) Reduced service disruptions from asset failure
(iv) Better budgeting for asset maintenance activities

Asset maintenance programs can be categorized into reactive and planned maintenance.

Reactive Maintenance is maintenance: Work performed after a breakdown. It is expensive and unplanned. it can be further sub-classified into Emergency and Non-emergency maintenance. Emergency maintenance is undertaken in times of an emergency while non-emergency maintenance is undertaken witout the presence of an emergency

Planned (Program Driven) Maintenance: alludes to the fact that this work would be scheduled and be part of a master plan for asset maintenance. It can be further subdivided into preventative and predictive maintenance. e Preventive Maintenance is routine work to keep an asset operating at peak performance while Predictive Maintenance is routine investigative work designed to determine when an asset may fail.

Asset Maintenance Plan

An asset maintenance plan provides governance of all aspect of the maintenance function required to sustain the asset over its life cycle. It is much more than a simple listing of preventive or predictive maintenance tasks

Asset maintenance strategies

Asset maintenance strategies are aimed at maintaining assets at an adequate standard by addressing statutory, technical and operational requirements that will incorporate a combination of:

a. **Preventative time-based maintenance -** this is undertaken at predetermined time intervals as required by statutory, technical or operational reliability considerations. This may be applied to building structures, fabric, services and site improvements, but is used predominantly for the maintenance of services;

b. **Condition-Based Maintenance -** this is undertaken as a result of an asset's condition and driven by the condition assessment process. This will apply to all building structures, fabric, services and site improvements;

c. **Zero-Based Maintenance -** apart from statutory and workplace health and safety requirements, no maintenance action is undertaken until breakdown or the asset quality falls below the minimum standard specified for the asset. Zero-based maintenance may be used for minor non-critical assets and those assets planned for refurbishment, replacement or disposal.

Review questions

1. Distinguish between asset management and asset and maintenance
2. Highlight the objectives of asset maintenance
3. Outline the components of an asset management plan
4. Outline three strategies adopted for asset management
5. List four advantages of asset maintenance

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QUALITY CONTROL AND APPRAISAL TECHNIQUES

Objectives:

(i) Define the term control
(ii) Highlight the dimensions quality
(iii) Describe the costs of quality
(iv) Define the concept of total quality management (TQM)

Introduction

Quality can have the following meanings:

- the characteristics of a product or service that bear on its ability to satisfy stated or implied needs, and
- a product or service free of deficiencies
- it could also be defined as conformance to customer expectations

Dimensions of quality

(i) **Performance:** Primary product characteristics, such as the brightness of the picture
(ii) **Features:** Secondary characteristics, added features, such as remote control
(iii) **Conformance:** Meeting specifications or industry standards, workmanship
(iv) **Reliability:** Consistency of performance over time, average time of the unit to fail
(v) **Durability:** Useful life, includes repair
(vi) **Service:** Resolution of problems and complaints, ease of repair
(vii) **Response:** Human – to – human interface, such as the courtesy of the dealer
(viii) **Aesthetics:** Sensory characteristics, such as exterior finish
(ix) **Reputation:** Past performance and other intangibles, such as being ranked first

Quality Planning

The following are the important steps for quality planning:

1. Establishing quality goals.
2. Identifying customers.
3. Discovering customer needs.
4. Developing product features.
5. Developing process features.
6. Establishing process controls and transferring to operations.

Quality Costs

Quality costs are defined as those costs associated with the non- achievement of product/service quality as defined by the requirements established by the organization and its contracts with customers and society. Quality cost is a cost for poor product of service. Quality cost comprise of:

(i) C o s t of prevention
(ii) C o s t of appraisal
(iii)C o s t of internal failures
(iv)C o s t of external failures.

i. **Prevention Cost:** costs incurred to prevent quality failures e.g. Marketing / Customer / User, Product / Service / Design Development, Purchasing, Operations (Manufacturing or Service), Quality Administration.
ii. **Appraisal Cost**: cost incurred in determining whether quality has been met e.g. Purchasing Appraisal Costs, Operations Appraisal Costs, External Appraisal Costs, Review of Test and Inspection Data, Miscellaneous Quality Evaluations

iii. **Internal Failure Cost**: costs incurred due internally due to quality failure e.g. Product or Service Design Failure Costs (Internal), Purchasing Failure Costs, Operations (Product or Service) Failure Costs

iv. **External Failure Cost**: costs incurred externally due to quality failure e.g. Complaint Investigations of Customer or User Service, Returned Goods, Retrofit and Recall Costs, Warranty Claims, Liability Costs, Penalties, Customer or User Goodwill, Lost Sales

Analysis Techniques Of Quality Cost

The purpose of quality cost analysis is to determine the cost of maintaining a certain level of quality. Such activity is necessary to provide feedback to management on the performance of quality assurance and to assist management in identifying opportunities. These techniques include index numbers, trend analysis and pareto analysis

Index Numbers :

Index Numbers are often used in a variety of applications to measure prices, costs (or) other numerical quantities and to aid managers in understanding how conditions in one period compare with those in other periods.

Trend Analysis:

Good visual aids are important communication tools. Graphs are particularly useful in presenting comparative results to management. Trend Analysis is one where Time-to-Time comparisons can be made which illustrates deviation in quality over time

Pareto Analysis:

Joseph Juran observed that most of the quality problems are generally created by only a few causes. For example, 80% of all internal failures are due to one (or) two manufacturing problems. Identifying these "vital few" and ignoring the "trivial many" will make the corrective action give a high return for a low money input

Quality Systems

ISO 9000 provides a standard quality standard between suppliers and a customer that helps to reduce the complexity of managing a number of different quality standards when a customer has many suppliers. ISO 9000 is a series of standards for quality management and assurance and has five major subsections as follows:

ISO 9000 provides guidelines for the use of the following four standards in the series.
ISO 9001 applies when the supplier is responsible for the development, design, production, installation, and servicing of the product.
ISO 9002 applies when the supplier is responsible for production and installation.
ISO 9003 applies to final inspection and testing of products.
ISO 9004 provides guidelines for managers of organisations to help them to develop their quality systems. It gives suggestions to help organisations meet the requirements of the previous four standards.

Total Quality Management (TQM)

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 the organisation and all parts of the 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 the organisation.

Emphasis of TQM

1. The customer defines quality and thus, their needs must be met.
2. Quality is the responsibility of all employees in all parts of the organisation
3. Identify and minimise all costs of quality
4. A continuous improvement culture must be developed to instil a culture which recognises the importance of quality to performance
5. A use of systems and procedures for improvement

1. The customer defines quality: This implies a need to discover customer needs and then focus quality improvement on meeting them. So the customer should be the focus of decision making, but operations managers should still assess what is feasible for the organisation to do.
2. Quality is the responsibility of all employees in all parts of the organization: All staff, whether directly involved in production/ customer contact, or not can set in motion a chain of events which customers will eventually see as poor quality products or services. Staff are required not only to avoid mistakes, but think positively about improving how they perform their jobs. Service Levels Agreements (SLA) provide a formal definition of service between internal areas of the organisation
3. Identify and minimise all costs of quality: Quality gurus argue that the cost of poor quality and thus the benefits of improvement in quality should be identified, so quality costs can be classified:
4. A continuous improvement culture must be developed: TQM espouses the process of continuous improvement (CI).
5. A use of systems and procedures for improvement: A key aspect of TQM is developing the procedures which support improvement. ISO 9000 provides a quality standard between suppliers and a customer developed by the International Organisation for Standardisation. Having a predefined quality standard reduces the complexity of managing a number of different quality standards when a customer has many suppliers. The standard is general enough to apply to almost any good or service, but it is the specific organisation or facility that is registered or certified to the standard. Other programmes which attempt to provide national and international standards for quality are the European Quality Award (EQA) and the Deming Prize.

TQM techniques

2 techniques associated with TQM and used to improve quality in operations are Statistical Process Control (SPC) and Six Sigma.

Statistical Process Control (SPC):

Statistical Process Control (SPC) is a sampling technique which checks the quality of an item which is engaged in a process. SPC should be seen as a quality check for process rather than product design. Quality should be built in to the product during the design stage. SPC works by identifying the nature of variations in a process, which are classified as being caused by 'chance' causes or 'assignable' causes.

-Chance Causes of Variation:All processes will have some inherent variability due to factors such as ambient temperature, wear of moving parts or slight variations in the composition of the material that is being processed. The technique of SPC involves calculating the limits of these chance-cause variations for a stable system, so any problems with the process can be identified quickly.

-Assignable Causes of Variation: If an 'out-of-control' process is

discovered, then it is assumed to have been caused by an assignable cause of variation. This is a variation in the process which is not due to random variation but can be attributed to some change in the process, which needs to be investigated and rectified.

The limits of the chance-cause variations are called control limits and are shown on a control chart, which also shows sample data of the measured characteristic over time. There are control limits above and below the target value for the measurement, termed the upper control limit (UCL) and lower control limit (LCL) respectively.

Six Sigma

Six Sigma is a quality improvement initiative to achieve quality levels which are within 6 sigma control limits, corresponding to a rate of 3.4 defective parts per million (PPM). Thus 6 sigma can be defined as the process of comparing process outputs against customer requirements. However 6-sigma has developed from this examination of process variation to become a companywide initiative to reduce costs through process efficiency and increase revenues through process effectiveness. 6 sigma has an emphasis on training – level of expertise is denoted by black belt, green belt etc. Six Sigma contains plans for both increasing effectiveness and efficiency leading to so increased revenues and thus improving company performance.

- Improving Effectiveness: The level of effectiveness of the organisation is reflected in the level of customer satisfaction. This means that efforts to improve effectiveness will focus on identifying and meeting internal and external customer requirements.

- Improving Efficiency: The aim of every process improvement approach using Six Sigma is to achieve measurable cost savings through a focus on decreasing process variation.

The DMAIC Methodology

6 sigma incorporates a structured approach to improvement called DMAIC. This is a five step methodology of define, measure, analyse, improve and control and is used to both improve process performance and to improve process or product design. It is a cyclical approach like the PDCA cycle.

- Define – Identify a potential area of improvement and define the project scope.
- Measure – Decide what characteristics of the process require improvement.
- Analyse – Use the data collected in the measure phase to document current performance.
- Improve – Eliminate the root causes of non-random variation to achieve improvements in predictability, dispersion and centering.
- Control – Verify and embed the change through the use of techniques such as control charts

Review questions

1. Define the term quality
2. Outline at least five dimensions of quality
3. Describe the concept of total quality management
4. Enumerate the steps involved in implementing total quality management
5. Explain the steps of the DMAIC methodology

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CAPACITY PLANNING

Objectives:

By the end of the chapter the student should be able to:

(i) Define the term capacity
(ii) Explain the components of capacity planning
(iii) Evaluate capacity plans
(iv) Explain the various demand management strategies

Introduction

Capacity comprises the resources to serve customers, process information or make products and is a mix of the people, systems, equipment and facilities needed to meet the services or products involved. A definition of capacity should take into account both the volume and the time over which capacity is available. Thus capacity can be taken as a measure of an organisation's ability to provide customers with services or goods in the amount requested at the time requested. Capacity decisions should be taken by firstly identifying capacity requirements and then evaluating the alternative capacity plans generated.

Identifying Capacity Requirements

This stage consists of both estimating future customer demand but also determining current capacity levels to meet that demand.

Measuring Demand

In a capacity planning context the business planning process is driven by two elements; the company strategy and forecasts of demand for the product/service the organisation is offering to the market. Demand forecasts will usually be developed by the marketing department and their accuracy will form an important element in the success of any capacity management plans implemented by operations. The demand forecast should express demand requirements in terms of the capacity constraints applicable to the organisation. This could be machine hours or worker hours as appropriate.The demand forecast should permit the operations manager to ensure that enough capacity is available to meet demand at a particular point in time, whilst minimising the cost of employing too much capacity for demand needs. The amount of capacity supplied should take into account the negative effects of losing an order due to too little capacity and the increase in costs on the competitiveness of the product in its market. Organisations must develop forecasts of the level of demand they should be prepared to meet. The forecast provides a basis for co-ordination of plans for activities in various parts of the organisation. For example personnel employ the right amount of people, purchasing order the right amount of material and finance can estimate the capital required for the business. Forecasts can either be developed through a qualitative approach or a quantitative approach.

Measuring Capacity

When measuring capacity it must be considered that capacity is not fixed but is a variable that is dependent on a number of factors such as the product mix processed by the operation and machine setup requirements. When the product mix can change then it can be more useful to measure capacity in terms of input measures, which provides some indication of the potential output. Also for planning purposes when demand is stated in output terms it is necessary to convert input measures to an estimated output measure. For example in hospitals which undertake a range of activities, capacity is often measured in terms of beds available (an input) measure. An output measure such as number of patients treated per week will be highly dependent on the mix of activities the hospital performs. The theoretical design capacity of an operation is rarely met due to such factors as maintenance and machine setup time between different products so the effective capacity is a more realistic measure. However this will also be above the level of capacity which is available due to unplanned occurrences such as a machine breakdown.

Evaluating Capacity Plans

The organisation's ability to reconcile capacity with demand will be dependent on the amount of flexibility it possesses. Flexible facilities allow organisations to adapt to changing customer needs in terms of product range and varying demand and to cope with capacity shortfalls due to equipment breakdown or component failure. The amount of flexibility should be determined in the context of the organisation's competitive strategy. Methods for reconciling capacity and demand can be classified into three 'pure' strategies of:

(i) level capacity

(ii) chase demand and

(iii) demand management

In practice a mix of these three strategies will be implemented.

Level Capacity

This approach fixes capacity at a constant level throughout the planning period regardless of fluctuations in forecast demand. This means production is set at a fixed rate, usually to meet average demand and inventory is used to absorb variations in demand. During periods of low demand any overproduction can be transferred to finished goods inventory in anticipation of sales at a later time period. The disadvantage of this strategy is the cost of holding inventory and the cost of perishable items that may have to be discarded. To avoid producing obsolete items firms will try to create inventory for products which are relatively certain to be sold. This strategy has limited value for perishable goods. For a service organisation output cannot be stored as inventory so a level capacity plan involves running at a uniformly high level of capacity. The drawback of this approach is the cost of maintaining this high level of capacity although it could be relevant when the cost of lost sales is particularly high, for example in a high value retail outlet such as a luxury car outlet where every sale is very profitable.

Chase Demand

This strategy seeks to change production capacity to match the demand pattern over time. Capacity can be altered by various policies such as changing the amount of part-time staff, changing the amount of staff availability through overtime working, changing equipment levels and subcontracting. The chase demand strategy is costly in terms of the costs of changing staffing levels and overtime payments. The costs may be particularly high in industries in which skills are scarce. Disadvantages of subcontracting include reduced profit margin lost to the subcontractor, loss of control, potentially longer lead times and the risk that the subcontractor may decide to enter the same market. For these reasons a pure chase demand strategy is more usually adopted by service operations which cannot store their output and so make a level capacity plan less feasible.

Demand Management

While the level capacity and chase demand strategies aim to adjust capacity to match demand, the demand management strategy attempts to adjust demand to meet available capacity. There are many ways this can be done, but most will involve altering the marketing mix and will require co-ordination with the marketing function. Demand Management strategies include:

- Varying the Price - During periods of low demand price discounts can be used to stimulate the demand level. Conversely when demand is higher than the capacity limit, price could be increased.
- Provide increased marketing effort to product lines with excess capacity.
- Use advertising to increase sales during low demand periods.
- Use the existing process to develop alternative product during low demand periods.
- Offer instant delivery of product during low demand periods.
- Use an appointment system to level out demand.

Review questions

1. Define the term capacity
2. Outline the steps involved in capacity planning
3. Outline the demand management strategies you are familiar with
4. Discuss five demand management strategies
5. Distinguish between chase demand and level capacity strategies

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LEAN OPERATIONS AND JUST IN TIME (JIT) MANAGEMENT

Objectives:

By the end of the chapter the student should be able to:

(i) Highlight the main objective of lean management

(ii) Discuss the key elements of lean operations

(iii) Describe the concept of just in time

(iv) Explain the key elements of just in time

Lean operations

Lean operations aims to meet demand instantly, deliver perfect quality and eliminate waste in all its forms. five key elements of Lean Operations are:

(i) eliminate waste,

(ii) involve everyone and

(iii) continuous improvement.

(i) Eliminate Waste

Waste is considered as any activity which does not add value to the operation. There are 7 classified types of wastes, the priority should be to avoid these wastes.

Types of waste

- Overproduction – making too much too early
- Waiting – Need to keep a low of material/customers
- Unnecessary Motions – ergonomics and layout
- Transporting – unnecessary movements/handling
- Processing – Too much capacity in one machine instead of a number of smaller ones
- Inventory – Raw material, work in progress and inished goods
- Defects – costs of defects tend to escalate the longer they remain undetected

The 7 service customer wastes can be the basis for an improvement programme:

- Delay on the part of customers waiting for service, for delivery, in queues, for response, not arriving as promised.
- Duplication. Having to re-enter data, repeat details on forms and answering queries from several sources within the same organisation.
- Unnecessary movements. Queuing several times, poor ergonomics in the service encounter.
- Unclear communication and the wastes of seeking clarification.

- Incorrect inventory. Out-of-stock, unable to get exactly what is required, substitute products or services.
- Opportunity lost to retain or win customers, failure to establish rapport, ignoring customers, unfriendliness, and rudeness.
- Errors in the service transaction, product defects in the product-service bundle, lost or damaged goods.

(ii) Involvement of Everyone

Some organisations view the lean approach as consisting almost exclusively of waste elimination. However effective waste elimination is best achieved through changes in staff behaviour. Lean aims to create a new culture in which all employees are encouraged to contribute to improvement efforts through generating ideas. In order to undertake this level of involvement the organisation will provide training to staff in a wide range of areas, including techniques such as statistical process control (SPC) and more general problem solving techniques.

(iii) Continuous Improvement (CI)

Continuous Improvement or Kaizen, the Japanese term, is a philosophy which believes that it is possible to get to the ideals of Lean by a continuous stream of improvements over time. Continuous Improvement is needed because customer's views are continually changing and standards are rising. Kaizen is about moving tacit knowledge to explicit knowledge.

Tacit – 'Know-How' based on years of experience but may not be written down. Explicit – Written down in principles and procedures. CI enables ideas held tacitly to be explicitly incorporated by the organisation. Principles for implementing a continuous improvement effort include:

Implementing Lean operations

As stated earlier the 'lean' approach aims to meet demand instantly, deliver perfect quality and eliminate waste in all its forms. One of the ways it does this is through replacing the traditional push production system with a pull production system sometimes called 'lean synchronisation.' Other techniques include setup reduction and total preventative maintenance.

Push Production Systems

In a push production system a schedule pushes work on to machines which is then passed through to the next work centre. At each production stage a buffer stock is kept to ensure that if any production stage fails then the subsequent production stage will not be starved of material. The higher the buffer stocks kept at each stage of the line, the more disruption can occur without the production line being halted by lack of material.

Advantages

- Buffers insulate stages against disruption in other stages.

Disadvantages

- Because buffers insulate system from problems the problems are not visible so no one takes responsibility for f i xing them.
- Buffer stock leads to high inventory and slower lead times
- Production is not connected to demand

Pull production system

In a pull system the process starts by an order for the finished product (e.g. car) at the end of the production line. This then triggers an order for components of that item which in turn triggers an order for further sub-components. The process repeats until the initial stage of production and the material lows through the system as in the push approach.

Advantages

- No buffers so problems visible (whole line stops) so people take responsibility for ixing them.
- No or low buffer stock leads to low inventory and faster lead times
- Production is connected (pulled) to demand

Disadvantages

- No protection against unforeseen disruptions to supply chain

One system for implementing a pull system is called a kanban (Japanese for 'card' or 'sign') production system. Each kanban provides information on the part identiication, quantity per container that the part is transported in and the preceding and next work station. Kanbans in themselves do not provide the schedule for production but without them production cannot take place as they authorise the production and movement of material through the pull system. Kanbans need not be a card, but something that can be used as a signal for production such as a marker, or coloured square area

Setup Reduction

In order to operate with the small batch sizes required by lean it is necessary to reduce setup time (the time taken to adjust equipment to work on a different component) drastically because of the increased number of setups needed with small batches. Originally some operations such as stamping car door panels with a press die were done in very large batch sizes, and the output stored in inventory, because the setup time for the press could be measured in hours or even days. Shigeo Shingo developed a system for setup reduction which became known as the Single Minute Exchange of Dies (SMED)

Total Preventative Maintenance (TPM)

This anticipates equipment failures through a programme of routine maintenance which will not only help to reduce breakdowns, but also to reduce downtime and lengthen the life of the equipment. TPM includes the following activities:

- Regular Maintenance activities such as lubricating, painting, cleaning and inspection. These activities are normally carried out by the operator in order to prevent equipment deterioration.
- Periodic Inspection to assess the condition of equipment in order to avoid breakdowns. These inspections are normally carried out at regular time intervals by either operator or maintenance personnel.
- Preventative Repairs, due to deterioration, but before a breakdown has occurred. Normally carried out by maintenance personnel but ideally by the operators.

Just-In-Time (JIT) Production

Just-in-time (JIT) is defined as "a philosophy of manufacturing based on planned elimination of all waste and on continuous improvement of productivity". It also has been described as an

approach with the objective of producing the right part in the right place at the right time (in other words, "just in time"). Waste results from any activity that adds cost without adding value, such as the unnecessary moving of materials, the accumulation of excess inventory, or the use of faulty production methods that create products requiring subsequent rework. JIT (also known as lean production or stockless production) should improve profits and return on investment by reducing inventory levels (increasing the inventory turnover rate), reducing variability, improving product quality, reducing production and delivery lead times, and reducing other costs (such as those associated with machine setup and equipment breakdown). In a JIT system, underutilized (excess) capacity is used instead of buffer inventories to hedge against problems that may arise.

JIT applies primarily to repetitive manufacturing processes in which the same products and components are produced over and over again. The general idea is to establish flow processes (even when the facility uses a jobbing or batch process layout) by linking work centers so that there is an even, balanced flow of materials throughout the entire production process, similar to that found in an assembly line. To accomplish this, an attempt is made to reach the goals of driving all inventory buffers toward zero and achieving the ideal lot size of one unit.

The basic elements of JIT were developed by Toyota in the 1950's, and became known as the Toyota Production System (TPS). JIT was well-established in many Japanese factories by the early 1970's. JIT began to be adopted in the U.S. in the 1980's (General Electric was an early adopter), and the JIT/lean concepts are now widely accepted and used.

Key Elements of JIT

1. Stabilize and level the MPS with uniform plant loading (heijunka in Japanese): create a uniform load on all work centers through constant daily production (establish **freeze windows** to prevent changes in the production plan for some period of time) and mixed model assembly (produce roughly the same mix of products each day, using a repeating sequence if several products are produced on the same line). Meet demand fluctuations through end-item inventory rather than through fluctuations in production level. Use of a stable production schedule also permits the use of backflushing to manage inventory: an end item's bill of materials is periodically exploded to calculate the usage quantities of the various components that were used to make the item, eliminating the need to collect detailed usage information on the shop floor.

2. Reduce or eliminate setup times: aim for single digit setup times (less than 10 minutes) or "one-touch" setup -- this can be done through better planning, process redesign, and product redesign. A good example of the potential for improved setup times can be found in auto racing, where a NASCAR pit crew can change all four tires and put gas in the tank in under 20 seconds. (How long would it take you to change just one tire on your car?) The pit crew's efficiency is the result of a team effort using specialized equipment and a coordinated, well-rehearsed process.

3. Reduce lot sizes (manufacturing and purchase): reducing setup times allows economical production of smaller lots; close cooperation with suppliers is necessary to achieve reductions in order lot sizes for purchased items, since this will require more frequent deliveries.

4. Reduce lead times (production and delivery): production lead times can be reduced by moving work stations closer together, applying group technology and cellular manufacturing concepts, reducing queue length (reducing the number of jobs waiting to be processed at a given machine), and improving the coordination and cooperation between successive processes; delivery lead times can be reduced through close cooperation with suppliers, possibly by inducing suppliers to locate closer to the factory.

5. Preventive maintenance: use machine and worker idle time to maintain equipment and prevent breakdowns.

6. Flexible work force: workers should be trained to operate several machines, to perform maintenance tasks, and to perform quality inspections. In general, JIT requires teams of competent, empowered employees who have more responsibility for their own work. The Toyota Production System concept of "respect for people" contributes to a good relationship between workers and management.

7. Require supplier quality assurance and implement a zero defects quality program: errors leading to defective items must be eliminated, since there are no buffers of excess parts. A quality at the source (**jidoka**) program must be implemented to give workers the personal responsibility for the quality of the work they do, and the authority to stop production when something goes wrong. Techniques such as "JIT lights" (to indicate line slowdowns or stoppages) and "tally boards" (to record and analyze causes of production stoppages and slowdowns to facilitate correcting them later) may be used.

8. Small-lot (single unit) conveyance: use a control system such as a **kanban** (card) system (or other signaling system) to convey parts between work stations in small quantities (ideally, one unit at a time). In its largest sense, JIT is not the same thing as a kanban system, and a kanban system is not required to implement JIT (some companies have instituted a JIT program along with a MRP system), although JIT is required to implement a kanban system and the two concepts are frequently equated with one another.

Review questions

1. Distinguish between lean operation and just in time
2. Describe the main elements of lean operations
3. Explain the process of implementing lean operations
4. Highlight the benefits of JIT
5. Enumerate the key elements of JIT approach to management

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BUSINESS PROCESS RE-ENGINEERING (BPR)

Objectives:

By the end of the chapter the student should be able to:

(i) Define the trm business process re-engineering
(ii) Outline the components of business process re-engineering
(iii) Highlight the advantages and disadvantages of functional structures
(iv) Explain the process of business process re-engineering

Introduction

Business process re-engineering (BPR) is the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed.

Components of business process re-engineering definition

- Fundamental rethinking – reengineering usually refers to the changing of signiicant business processes
- Radical redesign – involves a complete rethink about the way the business operates
- Dramatic improvements – tens or hundreds of percent improvement
- Critical contemporary measures of performance – process measures based on competitive factors of cost, quality, service and speed.

BPR stresses the use of information technology as a catalyst for these major changes. Examples given include decision support systems, teleconferencing and shared databases. BPR organises work around customer processes rather than functional hierarchies

Advantages of functional structures:

- Creates a pool of expertise which can service a number of areas
- Helps develop careers in a particular field

Disadvantages of functional structures:

- Focus of work can be on functional boss rather than end customer
- No one takes overall responsibility for overall process
- Tasks may be undertaken for internal functional reasons rather than overall business strategy

Implementing Business Process Redesign

The task of designing processes should be undertaken in a structured manner and the steps involved can be described as:

1. Identifying and documenting the process activities
2. Identifying processes for improvement
3. Evaluating process design alternatives

1. Identifying and documenting the process activities

The identification of activities in a current process design is a data collection exercise using methods such as examination of current documentation, interviews, and observation. In order to provide a framework for the design and improvement of service processes the techniques of process mapping and service blueprinting can be utilised.

2. Identifying processes for improvement

The identification of the relevant business processes for improvement can be undertaken using a scoring system in which prioritisation is governed by importance to customers and performance against competitors. Other measurement systems can be used such as a process marking guide covering the amount of impact and extent of innovation required of a process to meet performance across a number of critical success factors.

3. Evaluating Process Design Alternatives

There are many ways in which a process can be designed to meet particular objectives and so it is necessary to generate a range of innovative solutions for evaluation. Three approaches which can be used to generate new ideas are:

- Generating new designs through brainstorming

This approach offers the greatest scope for radical improvements to the process design but represents a risk in the implementation of a totally new approach.

- Modifying Existing Designs

This approach is less risky than a blue skies approach but may mean the opportunity for a radical improvement in process design is missed

- Using an established 'benchmark' design

This approach applies the idea of identifying the best-in-class performer for the particular process in question and adopting that design.

Review questions

1. Define the term business process re-engineering
2. Highlight the components of BPR
3. Explain the process of BPR
4. Identify two advantages of functional structures
5. Outline three approaches which can be used to generate ideas for BPR

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OPERATIONS PLANNING AND CONTROL

Objectives:

By the end of the chapter the student should be able to:

(i) Distinguish between operations planning and control

(ii) Explain the activities involved in operations planning

(iii) Explain the activities involved in operations control

(iv) Outline the benefits of operations planning and control

Introduction

Planning and control are different but very closely related. Planning is the theoretical end of the activity, while control is the more applied end. Planning involves deciding what to do and when to do it. Control involves making sure that plans are actually taking place in practice and responding when things do not according to plan. Planning looks at activities sometime in the future. Control looks at activities that are happening now. (Of course 'now' can mean this minute, this hour, today, this week, this month, etc. It is all relative). The point being that there is an immediacy about control that is not there in planning. However, because control involves taking circumstances into account and re-planning, control inevitably involves making plans (or more accurately, making new plans).

Planning and control involve generally the organization and planning of manufacturing process. Especially it consists of the planning of routing, scheduling, dispatching inspection, and coordination, control of materials, methods machines, tools and operating times. The ultimate objective is the organization of the supply and movement of materials and labour, machines utilization and related activities, in order to bring about the desired manufacturing results in terms of quality, quantity, time and place.

Benefits of planning and control

(1) Optimum Utilisation of Capacity: With the help of Planning and Control [PPC] the operations manager can schedule his tasks and production runs and thereby ensure that his productive capacity does not remain idle and there is no undue queuing up of tasks via proper allocation of tasks to the production facilities. No order goes unattended and no machine remains idle.

(2) Inventory control: Proper planning and control will help to resort to just- in- time systems and thereby reduce the overall inventory. It will ensure the right supplies are available at the right time.

(3) Economy in production time: planning and control will help to reduce the cycle time and increase the turnover via proper scheduling.

(4) Ensure quality: good planning and control will provide for adherence to the quality standards so that quality of output is ensured.

Constraints on the planning and control task
Cost constraints – products and services must be produced within an identified cost.

- Capacity constraints – products and services must be produced within the designed capacity limits of the operation.
- Timing constraints – products and services must be produced within the time when they still have value for the customer.
- Quality constraints – products and services must conform to the designed tolerance limits of the product or service.

Steps in the planning and control
Production Planning involves:
Planning

Routing

Scheduling

Loading

Production control involves:

Dispatching

Following up

Inspection

Corrective

Production planning: Production planning may be defined as the technique of foreseeing every step in a long series of separate operations, each step to be taken at the right time and in the right place and each operation to be performed in maximum efficiency. It helps to work out the quantity of material manpower, machine and money requires for producing predetermined level of output in given period of time.

Routing: Under this, the operations, their path and sequence are established. To perform these operations the proper class of machines and personnel required are also worked out. The main aim of routing is to determine the best and cheapest sequence of operations and to ensure that this sequence is strictly followed. Routing procedure involves following different activities.

(1) An analysis of the article to determine what to make and what to buy.

(2) To determine the quality and type of material

(3) Determining the manufacturing operations and their sequence.

(4) A determination of lot sizes

(5) Determination of scrap factors

(6) An analysis of cost of the article

(7) Organization of production control forms.

Scheduling: It means working out of time that should be required to perform each operation and also the time necessary to perform the entire series as routed, making allowances for all factors concerned. It mainly concerns with time element and priorities of a job. The pattern of scheduling differs from one job to another which is explained as below:

(a) Production schedule: The main aim is to schedule that amount of work which can easily be handled by plant and equipment without interference. Its not independent decision as it takes into account following factors.

(1) Physical plant facilities of the type required to process the material being scheduled.

(2) Personnel who possess the desired skills and experience to operate the equipment and perform the type of work involved.

(3) Necessary materials and purchased parts.

(b) Master Schedule: Scheduling usually starts with preparation of master schedule which is weekly or monthly break-down of the production requirement for each product for a definite time period, by having this as a running record of total production requirements the entrepreneur is in better position to shift the production from one product to another as per the changed production requirements. This forms a base for all subsequent scheduling acclivities. A master schedule is followed by operator schedule which fixes total time required to do a piece of work with a given machine or which shows the time required to do each detailed operation of a given job with a given machine or process.

(c) Manufacturing schedule: It is prepared on the basis of type of manufacturing process involved. It is very useful where single or few products are manufactured repeatedly at regular intervals. Thus it would show the required quality of each product and sequence in which the same to be operated

(d) Scheduling of Job order manufacturing: Scheduling acquires greater importance in job order manufacturing. This will enable the speedy execution of job at each center point. Scheduling is of utmost importance as it brings out efficiency in the operations and reduces cost price. The small entrepreneur should maintain four types of schedules to have a close scrutiny of all stages

namely an enquiry schedule, a production schedule, a shop schedule and an arrears schedule out of above four, a shop schedule is the most important most suited to the needs of small scale industry as it enables a foreman to see at a glance.

1. The total load on any section

2. The operational sequence

3. The stage, which any job has reached.

Loading: The next step is the execution of the schedule plan as per the route chalked out it includes the assignment of the work to the operators at their machines or work places. So loading determines who will do the work as routing determines where and scheduling determines when it shall be done. Gantt Charts are most commonly used in small industries in order to determine the existing load and also to foresee how fast a job can be done. The usefulness of their technique lies in the fact that they compare what has been done and what ought to have been done.

Production control: Production control is the process of planning production in advance of operations, establishing the extract route of each individual item part or assembly, setting, starting and finishing for each important item, assembly or the finishing production and releasing the necessary orders as well as initiating the necessary follow-up to have the smooth function of the enterprise. The production control is of complicated nature in small industries. The production planning and control department can function at its best only when the work manager, the purchase manager, the personnel manager and the financial controller assist in planning production activities. The production controller directly reports to the works

Dispatching: Dispatching involves issue of production orders for starting the operations. Necessary authority and conformation is given for:

1. Movement of materials to different workstations.

2. Movement of tools and fixtures necessary for each operation.

3. Beginning of work on each operation.

4. Recording of time and cost involved in each operation.

5. Movement of work from one operation to another in accordance with the route sheet.

6. Inspecting or supervision of work

Dispatching is an important step as it translates production plans into production.

Follow up: Every production programme involves determination of the progress of work, removing bottlenecks in the flow of work and ensuring that the productive operations are taking place in accordance with the plans. It spots delays or deviations from the production plans. It helps to reveal detects in routing and scheduling, misunderstanding of orders and instruction, under loading or overloading of work etc. All problems or deviations are investigated and remedial measures are undertaken to ensure the completion of work by the planned date.

Inspection: This is mainly to ensure the quality of goods. It can be required as effective agency of production control.

Corrective measures: Corrective action may involve any of those activities of adjusting the route, rescheduling of work changing the workloads, repairs and maintenance of machinery or equipment, control over inventories of the cause of deviation is the poor performance of the employees. Certain personnel decisions like training, transfer, demotion etc. may have to be taken. Alternate methods may be suggested to handle peak loads.

Review questions

1. Highlight the Benefits of planning and control
2. Outline the Constraints on the planning and control task
3. Describe the Steps in the planning and control
4. Outline the activities involved Production control
5. Outline the activities involved in Production Planning

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PROJECT MANAGEMENT

Objectives:

By the end of the chapter the student should be able to:

(i) Define the term project
(ii) Explain the project management activities
(iii) Draw a project network diagram
(iv) Draw a project Gantt chart

Introduction

A project is an interrelated set of activities with a definite starting and ending point, which results in a unique outcome for a specific allocation of resources. The complexity of the project will increase with the size and number of activities within the project. Extensive planning and co-ordination activities are required for larger projects to ensure that the project aims are met. Examples of projects include installing an IT system, building a bridge or introducing a new service or product to the market.

Project Management Activities

The project management process includes the following main elements:

(i) Feasibility Analysis: This step involves evaluating the expected cost of resources needed to execute the project and compare these to expected benefits. At the start of the project a plan of the resources required to undertake the project activities is constructed. If there is a limit on the amount of resources available then the project completion date may have to be set to ensure the resources are not overloaded. This is a resource-constrained approach. Alternatively the need to complete the project by a specific date may take precedence. In this case an alternative source of resources may have to be found, using sub- contractors for example, to ensure timely project completion. This is called a time-constrained approach.

(ii) Plan: This stage estimates the amount and timing of resources needed to achieve the project objectives. The project management method uses a systems approach to dealing with a complex task in that the components of the project are broken down repeatedly into smaller tasks until a manageable chunk is defined. Each task is given its own cost, time and quality objectives. It is then essential that responsibility is assigned to achieving these objectives for each particular task. This procedure should produce a work breakdown structure (WBS) which shows the hierarchical relationship between the project tasks.

(iii) Control: This stage involves the monitoring the progress of the project as it executes over time. This is important so that any deviations from the plan can be addressed before it is too near the project completion date to take corrective action. The point at which the project progress is assessed is termed a Milestone. The two main methods of reporting the progress of a project are by written reports and verbally at meetings of the project team. It is important that a formal statement of progress is made in written form, preferably in a standard report format, to ensure that everyone is aware of the current project situation. This is particularly important when changes to specifications are made during the project. In order to facilitate two-way communication between team members and team management, regular meetings should be arranged by the project manager. These meetings can increase the commitment of team members by allowing discussion of points of interest and dissemination of information on how each team's effort is contributing to the overall progression of the project.

Network Analysis

Network analysis/Project Evaluation and Review Technique (PERT) is a method to analyze the involved tasks in completing a given project, especially the time needed to complete each task, and to identify the minimum time needed to complete the total project. PERT was developed primarily to simplify the planning and scheduling of large and complex projects. It was developed for the U.S. Navy Special Projects Office in 1957 to support the U.S. Navy's Polaris nuclear submarine project. It was able to incorporate uncertainty by making it possible to schedule a project while not knowing precisely the details and durations of all the activities. It is more of an event-oriented technique rather than start- and completion-oriented, and is used more in projects where time is the major factor rather than cost. It is applied to very large-scale, one-time, complex, non-routine infrastructure and Research and Development projects

Terminology

PERT event: a point that marks the start or completion of one or more activities. It consumes no time and uses no resources. When it marks the completion of one or more activities, it is not "reached" (does not occur) until all of the activities leading to that event have been completed.

predecessor event: an event that immediately precedes some other event without any other events intervening. An event can have multiple predecessor events and can be the predecessor of multiple events.

successor event: an event that immediately follows some other event without any other intervening events. An event can have multiple successor events and can be the successor of multiple events.

PERT activity: the actual performance of a task which consumes time and requires resources (such as labor, materials, space, machinery). It can be understood as representing the time, effort, and resources required to move from one event to another. A PERT activity cannot be performed until the predecessor event has occurred.

PERT sub-activity: a PERT activity can be further decomposed into a set of sub-activities. For example, activity A1 can be decomposed into A1.1, A1.2 and A1.3 for example. Sub-activities have all the properties of activities, in particular a sub-activity has predecessor or successor events just like an activity. A sub-activity can be decomposed again into finer-grained sub-activities.

optimistic time (O): the minimum possible time required to accomplish a task, assuming everything proceeds better than is normally expected

pessimistic time (P): the maximum possible time required to accomplish a task, assuming everything goes wrong (but excluding major catastrophes).

most likely time (M): the best estimate of the time required to accomplish a task, assuming everything proceeds as normal.

expected time (T_E): the best estimate of the time required to accomplish a task, accounting for the fact that things don't always proceed as normal (the implication being that the expected time is the average time the task would require if the task were repeated on a number of occasions over an extended period of time).

$$T_E = (O + 4M + P) \div 6$$

float or slack is a measure of the excess time and resources available to complete a task. It is the amount of time that a project task can be delayed without causing a delay in any subsequent tasks (free float) or the whole project (total float). Positive slack would indicate ahead of schedule; negative slack would indicate behind schedule; and zero slack would indicate on schedule.

critical path: the longest possible continuous pathway taken from the initial event to the terminal event. It determines the total calendar time required for the project; and, therefore, any time delays along the critical path will delay the reaching of the terminal event by at least the same amount.

critical activity: An activity that has total float equal to zero. An activity with zero float is not necessarily on the critical path since its path may not be the longest.

Lead time: the time by which a predecessor event must be completed in order to allow sufficient time for the activities that must elapse before a specific PERT event reaches completion.

lag time: the earliest time by which a successor event can follow a specific PERT event.

fast tracking: performing more critical activities in parallel

crashing critical path: Shortening duration of critical activities

Network analysis involves the following steps:

(i) Identifying project activities

(ii) Estimating activity durations

(iii) Identifying activity relationships

(iv) Drawing the network diagram

Identifying Project Activities

In order to undertake network analysis it is necessary to break down the project into a number of identifiable activities or tasks. This enables individuals to be assigned responsibility to particular tasks which have a well-defined start and finish time. Financial and resource planning can also be conducted at the task level and co-ordinated by the

project manager who must ensure that each task manager is working to the overall project objectives and not maximising the performance of particular task at the expense of the whole project. Activities consume time and/or resources. The first stage in planning a project is to break down the project into a number of identifiable activities with a start and end. Performance objectives of time, cost and quality can be associated with each activity. The project is broken down into these tasks using a work breakdown structure. This is a hierarchical tree structure which shows the relationship between the tasks as they are further sub-divided at each level.

Identifying Project Activities

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Estimating Activity Durations

The next stage is to retrieve information concerning the duration of the tasks involved in the project. he can be collated from a number of sources, such as documentation, observation, interviewing etc. Obviously the accuracy of the project plan will depend on the accuracy of these estimates. There is a trade-off between the cost of collecting information on task duration's and the cost of an inaccurate project plan.

Identifying Activity Relationships

It is necessary to identify any relationships between tasks in the project. For instance a particular task may not be able to begin until another task has finished. Thus the task waiting to begin is dependent on the former task. Other tasks may not have a dependent relationship and can thus occur simultaneously. Critical path diagrams are used extensively to show the activities undertaken during a project and the dependencies between these activities. Thus it is easy to see that activity C for example can only take place when activity A and activity B has completed. Once a network diagram has been constructed it is possible to follow a sequence of activities, called a path, through the network from start to end. The length of time it takes to follow the path is the sum of all the durations of activities on that path. The path with the longest duration gives the project completion time. This is called the critical path because any change in duration in any activities on this path will cause the whole project duration to either become shorter or longer. Activities not on the critical path will have a certain amount of slack time in which the activity

can be delayed or the duration lengthened and not affect the overall project duration. The amount of slack is a function of the difference between the path duration the activity is on and the critical path duration. By definition all activities on the critical path have zero slack. It is important to note that there must be at least one critical path for each network and there may be several.

Drawing the Network Diagram

For the activity-on-node notation each activity task is represented by a node with the following format. hus a completed network will consist of a number of nodes connected by lines, one for each task, between a start and end node.

Calculating the Earliest Start/Finish times (forward pass): From the duration of each task and the dependency relationship between the tasks it is possible to estimate the earliest start and finish time for each task as follows. You move left to right along the network, forward through time.

1. Assume the start (i.e. first) task begins at time = 0.
2. Calculate the earliest finish time where: Earliest Finish = Earliest Start + Duration
3. Calculate the earliest start time of the next task where:-Earliest Start = Earliest Finish of task immediately before: If there is more than one task immediately before take the task with the latest finish time to calculate the earliest start time for the current task.
4. Repeat steps 2 and 3 for all tasks

Calculating the Latest Start/Finish times (backward pass): It is now possible to estimate the latest start and finish time for each task as follows. You move right to left along the network, backward through time.

1. Assume the end (i.e. last) task end time is the earliest finish time (unless the project end time is given).
2. Calculate the latest start time where:- Latest Start = Latest Finish - Duration
3. Calculate the latest finish time of the previous task where: Latest Finish = Latest Start of task immediately after. If there is more than one task immediately after take the task with the earliest start time to calculate the latest finish time for the current task.
4. Repeat steps 2 and 3 for all tasks

Calculating the slack/float times: The slack or float value is the difference between the earliest start and latest start (or earliest finish and latest finish) times for each task. To calculate the slack time

1. Slack = Latest Start - Earliest Start OR Slack = Latest Finish - Earliest Finish
2. Repeat step 1 for all tasks.

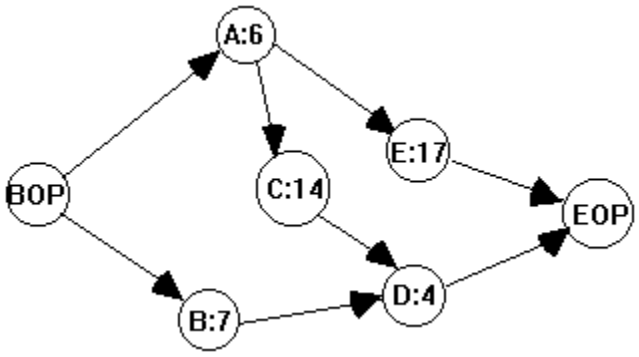
Identifying the Critical Path: Any tasks with a slack time of 0 must obviously be undertaken on schedule at the earliest start time. The critical path is the pathway connecting all the nodes with a zero slack time. There must be at least one critical path through the network, but there can be more than one. The significance of the critical path is that if any node on the path finishes later than the earliest finish time, the overall network time will increase by the same amount, putting the project behind schedule. Thus any planning and control activities should focus on ensuring tasks on the critical path remain within schedule.

Example:
Consider a small project that involves the following activities.

	Preceding	Completion Times (days)		
Activity	Activity	Optimistic	Most Likely	Pessimistic
a	-	5	6	7
b	-	4	5	18
c	A	4	15	20
d	b,c	3	4	5
e	A	16	17	18

Required: find the critical path

Solution:



By simple enumeration one finds that the critical path is A-C-D.

CP =A-C-D and the mean critical path duration is dcp = 6 + 14 + 4 = 24.

Gantt charts

Although network diagrams are ideal for showing the relationship between project tasks, they do not provide a clear

view of which tasks are being undertaken over time and particularly how many tasks may be undertaken in parallel at any one time. The Gantt chart provides an overview for the Project Manager to allow them to monitor project progress against planned progress and so provides a valuable information source for project control. A **Gantt chart** is a type of bar chart, developed by Henry Gantt in the 1910s, that illustrates a project schedule. Gantt charts illustrate the start and finish dates of the terminal elements and summary elements of a project. Terminal elements and summary elements comprise the work breakdown structure of the project.

To draw a Gantt Chart manually undertake the following steps:

- Draw a grid with the tasks along the vertical axis and the time-scale (up to the project duration) along the horizontal axis.
- Draw a horizontal bar across from the task identifier along the left of the chart starting at the earliest start time and ending at the earliest finish time.
- Indicate the slack amount by drawing a line from the earliest finish time to the latest finish time.

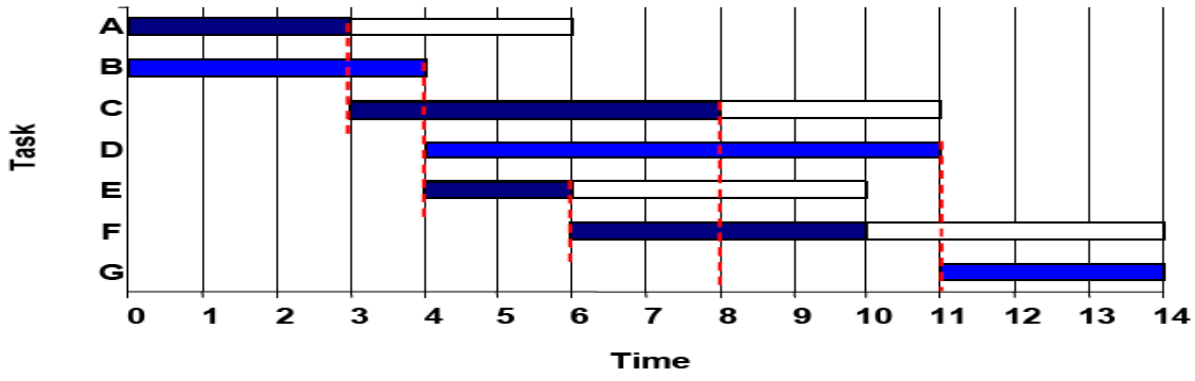
Example

The following activities relate to a particular project

Task	Duration	Precedence	ES	EF	LS	LF	Slack Time	Critical Task
A	3		0	3	3	6	3	N
B	4		0	4	0	4	0	Y
C	5	A	3	8	6	11	3	N
D	7	B	4	11	4	11	0	Y
E	2	B	4	6	8	10	4	N
F	4	E	6	10	10	14	4	N
G	3	C,D	11	14	11	14	0	Y

Required: prepare a Gantt chart from the above data

Solution:



Review questions

1. Define the term project
2. Explain the three main project activities
3. Explain the origin of network analysis
4. Describe the process of drawing a project network
5. Discuss the process of drawing a Gantt chart

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BENCHMARKING

Objectives:

By the end of the chapter the student should be able to:

(i) Define the term benchmarking
(ii) Explain the types of benchmarking
(iii) Discuss the benchmarking process
(iv) Define the concept of world class operations

Introduction

Benchmarking is the process of comparing one's business processes and performance metrics to industry bests or best practices from other industries. Benchmarking is about comparing and measuring your performance against others in key project activities, and then using lessons learned from the best to make targeted improvements. It involves answering two questions – who is better, and why is they better? – With the aim of using this information to make changes that will lead to real improvements. The best performance achieved in practice is the benchmark. A benchmark is the best in class level of performance achieved for a specific production process or activity. It is used as a reference point for comparison in the benchmarking process.

Dimensions typically measured are quality, time and cost. In the process of best practice benchmarking, management identifies the best firms in their industry, or in another industry where similar processes exist, and compares the results and processes of those studied (the "targets") to one's own results and processes. In this way, they learn how well the targets perform and, more importantly, the business processes that explain why these firms are successful.

Key performance indicators

A Key Performance Indicator (KPI) is the measure of performance associated with an activity or process critical to the success of a project or process. The information provided by a KPI can be used to determine how a process compares with the benchmark, and is therefore a key component in an organisation's move towards best practice and value for money.

Key performance indicators can take a variety of forms, which reflect the stakeholder interest. KPI's form part of many approaches to good business management and practice but it is important to note that KPI's should not just be viewed, an ad-hoc, or short term measure. The nature of KPI's means that, they should continually be reviewed and the information gained from them used effectively to increase productivity and economic efficiency. Therefore, the use of KPI's is a dynamic approach and thus, a framework should exist where these KPI's are regularly reviewed and adjusted if necessary

Types of benchmarking

(i) Internal benchmarking– a comparison of internal operations such as one site (or project

team) against another within the same company.

(ii) Competitive benchmarking – a comparison against a specific competitor for the product, service or function of interest.

(iii) Generic benchmarking – a comparison of business functions or processes that are the same, regardless of industry or country.

(iv) Functional benchmarking: Comparisons to similar functions within the same industry

(v) External Benchmarking**:** Involves analysing outside organisations that are known to be best in class. External benchmarking provides opportunities of learning from those who are at the "leading edge".

Process of benchmarking

i. **Identify problem areas:** Because benchmarking can be applied to any business process or function, a range of research techniques may be required. They include informal conversations with customers, employees, or suppliers; exploratory research techniques such as focus groups; or in-depth marketing research, quantitative research, surveys, questionnaires, re-engineering analysis, process mapping, quality control variance reports, financial ratio analysis, or simply reviewing cycle times or other performance indicators. Before embarking on comparison with other organizations it is essential to know the organization's function and processes; base lining performance provides a point against which improvement effort can be measured.

ii. **Identify other industries that have similar processes:** For instance, if one were interested in improving hand-offs in addiction treatment one would identify other fields that also have hand-off challenges. These could include air traffic control, cell phone switching between towers, transfer of patients from surgery to recovery rooms.

iii. **Identify organizations that are leaders in these areas:** Look for the very best in any industry and in any country. Consult customers, suppliers, financial analysts, trade associations, and magazines to determine which companies are worthy of study.

iv. **Survey companies for measures and practices:** Companies target specific business processes using detailed surveys of measures and practices used to identify business process alternatives and leading companies. Surveys are typically masked to protect confidential data by neutral associations and consultants.

v. **Visit the "best practice" companies to identify leading edge practices:** Companies typically agree to mutually exchange information beneficial to all parties in a benchmarking group and share the results within the group.

vi. **Implement new and improved business practices:** Take the leading edge practices and develop implementation plans which include identification of specific opportunities, funding the project and selling the ideas to the organization for the purpose of gaining demonstrated value from the process.

Advantages of benchmarking

i. Assists in Setting Strategic Targets
ii. Promotes Improvements in Performance
iii. Establishes a Competitive Edge
iv. Enhances Customer Satisfaction
v. Reduces Costs
vi. Improves Employee Morale
vii. Survival i.e. promotes business sustainability

Disadvantages of benchmarking

i. Difficulties getting agreement on what indicators are to be used.
ii. Difficulties in defining the data.
iii. Provides only limited information about how to correct performance shortfalls.
iv. The projects could be completed quickly but the results might take much longer time.
v. Highly ambitious goals might lead to unsuccessful benchmarking process.
vi. Several organizations prevent the procedure lest their weaknesses be exposed to their competitors.
vii. Cultural differences might, lead to some difficulties in applying best practices as happening Multi National Corporations.

World class operations

Being world-class in operations capabilities is crucial to survival, because world-class has become an order-qualifier rather than an order-winner. World class operations encompass the following aspects:

(i) Lean production: an organization must adopt Lean practices in order to be a world class organisation.
(ii) Quality: Quality in world class firms is about never giving up on quality, getting better in the areas where the firm already excels, and actively seeking out areas of improvement that do not appear to be important on the surface.
(iii) Innovation is also a major requirement for firms, although being first to market does not necessarily bring sustained success.
(iv) Alliances and partnerships: World class firms must also chose partners in a range of areas, and manage relationships with them. Enemies must become friends or allies as part of world-class operations.
(v) business ethics and corporate responsibility are part of world-class operations. This responsibility is likely to increase, as awareness in major ethical and environmental issues become greater.

Guidelines for effective benchmarking and achieving world class operations

i. **Commitment.** A strong determination to stay the course.

ii. **Communication.** Paying exceptional attention to employee comments and suggestions.

iii. **Culture Consciousness.** Fitting systems and programs into the culture.

iv. **Customer-focused.** Being proactively attentive to customer needs, both present and anticipated.

v. **Interdependence.** Recognizing the influence of one function's work on others.

vi. **Never Satisfied.** Being deeply committed to the continuous improvement ethic.

vii. **Relationship.** Building alliances to gain support and complete the work.

viii. **Risk Taking.** You need to take risks. Don't get sandbagged by your mistakes, he cautioned. Learn from them.

ix. **Strategy and Planning.** Doing what management books prescribe.

x. **Effective Change management**. A "world class" organization, must learn how to master change.

Review questions

1. Define the term 'Key performance indicators'
2. Describe the types of benchmarking
3. Outline the process of benchmarking
4. Highlight the Advantages of benchmarking
5. List six guidelines for effective benchmarking and achieving world class operations

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FAILURE PREVENTION AND RECOVERY

Objectives:

By the end of the chapter the student should be able to:

(i) define the term failure
(ii) identify the key types of failure
(iii) describe techniques of measuring failure
(iv) outline the methods for Failure detection and analysis

Introduction

Failure is the state or condition of not meeting a desirable or intended objective, and may be viewed as the opposite of success. Operations managers, who are almost always concerned with improving the dependability of their operations and the products and services which they produce, try to have strategies in place which attempt to minimise the likelihood of failure and learn from failure when it does occur, in spite of all the attempts to prevent them. What is then important is that they have plans in place which help them recover from the failures when they do occur.

Types of failure

(i) **Design failure:**Operations may look fine on paper but cannot cope with real circumstances
(ii) **Facilities failure:** All facilities (machines, equipment, buildings, fittings) are liable to breakdown.
(iii) **People failure:** Errors and violations by individuals
(iv) **Supplier failure:**A supplier failed to Deliver, Deliver on time, Deliver quality goods and services, can lead to failure within an operation.
(v) **Customer failure:** Customer failure can result when customers misuse products and services

Techniques of measuring failure

There are three main ways of measuring failure:

- **Failure rates** – how often a failure occurs
- **Reliability** – the chances of failure occurring
- **Availability** – the amount of available useful operating time

Failure detection and analysis

The Mechanisms used to detect failure include:

1. In process checks
2. Machine diagnostic check
3. Point-of-departure interviews
4. Phone surveys

5. Focus groups
6. Complaint cards of feedback sheets
7. Questionnaires

In process checks – employees check that the process is acceptable during the process.

Machine diagnostic check – a machine is put through a prescribed sequence of activities to expose any failures or potential failures.

Point-of-departure interviews – at the end of a service, staff may check that the service has been satisfactory.

Focus group – groups of customers are brought together to some aspects of a product or service.

Phone survey, **Complaint cards & Questionnaires** – these can be used to ask for opinions about products or services.

Failure Analysis

1. **Accident investigation**

   Trained staff analyse the cause of the accident and make recommendations to minimize or eradicate of the failure happening again. Specialized investigation technique suited to the type of accident

2. **Product liability**

   Ensures all products are traceable. Traced back to the process, the components from which they were produced and the supplier who supplied them. Goods can be recalled if necessary.

3. **Complaint analysis**

   Complaints and compliments are recorded and taken seriously. They are Cheap and easily available source of information about errors. It involves tracking number of complaints over time.

4. **Critical incident analysis**

   Requires customers to identify the elements of products or services they found either satisfying or not satisfying. It is especially used in service operations.

5. **Failure mode and effect analysis (FMEA)**

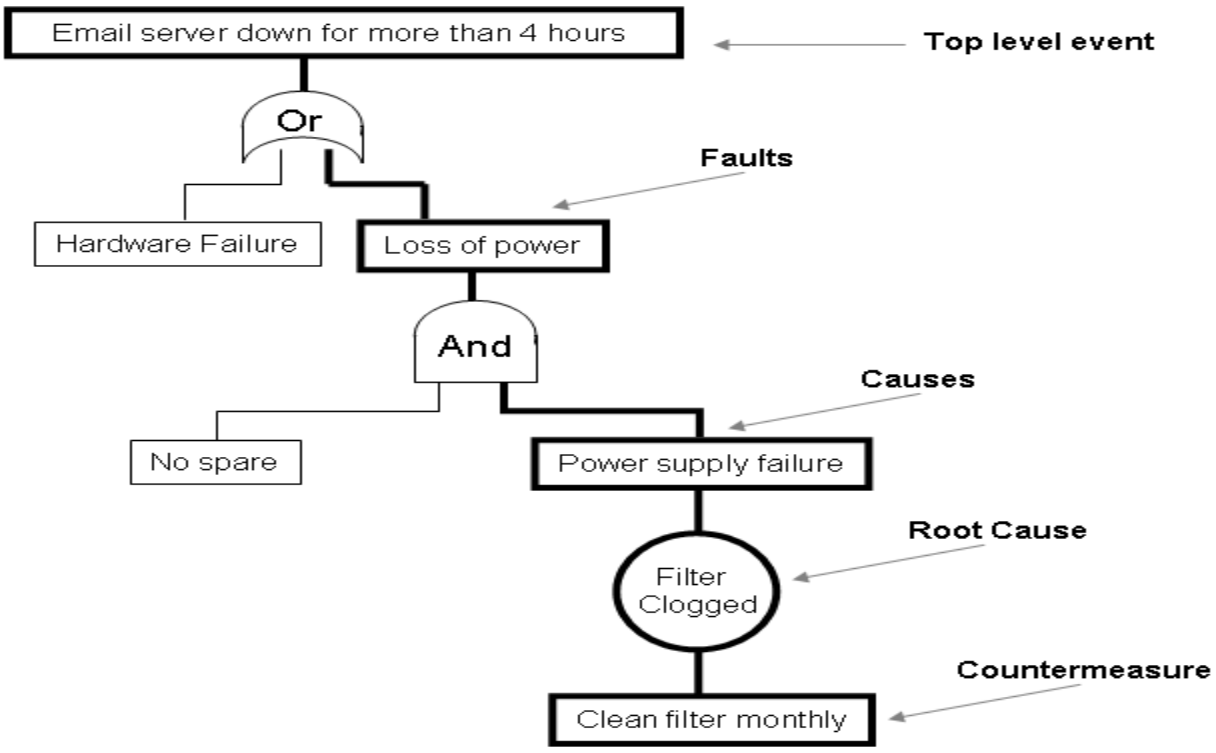
   Used to identify failure before it happens so proactive measures can be taken. For each possible cause of failure the following type questions are asked:

   1. What is the likelihood a failure will occur?
   2. What would the consequence of the failure be?
   3. How likely is such a failure to be detected before it affects the customer?

   Risk priority number (RPN) calculated based on these questions and Corrective action taken based on RPN.

6. **Fault-tree analysis**

   This is a logical procedure that starts with a failure or potential failure and works backwards to identify all the possible causes and therefore the origins of that failure. It's Made up of branches connected by AND nodes and OR nodes. Branches below AND node all need to occur for the event above the node to occur. Only one of the branches below an OR node needs to occur for the event above the node to occur. A fault tree diagram in relation to a server failure is given as an example below:



Improving operations Reliability/Ways of reducing failure

After the cause and effect of a failure is known, the next course of action is to try to prevent the failures from taking place. This can be done in a number of ways

i. Designing out fail points in the process
ii. Building redundancy into the process
iii. 'Fail-safeing' some of the activities in the process
iv. Maintenance of the physical facilities in the process

Designing out fail points

Identifying and then controlling process, product and service characteristics to try to prevent failures. Use of process maps to detect potential fail points in operations.

Redundancy

Building up redundancy to an operation means having back-up systems in case of failure.Increases the reliability of a component. It is an Expensive solution which is Used for breakdowns with critical impact

Fail-safeing

Called poka-yoke in Japan. It is Based on the principle that human mistakes are to some extent inevitable. The objective is to prevent them from becoming a defect. Poka-yokes are simple (preferably inexpensive) devices of systems which are incorporated into a process to prevent inadvertent operator mistakes resulting in a defect.

Maintenance

Maintenance is the method used by organizations to avoid failure by taking care of their physical activities. It is Important to organizations whose physical activities play a central role in creating their goods and service.

Review questions

1. List the key types of failure
2. Identify the techniques of measuring failure
3. Outline the methods for failure detection and analysis
4. Discuss the importance of failure analysis
5. Suggest ways of improving operations reliability/ways of reducing failure

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ROLE OF IT IN OPERATIONS MANAGEMENT

Objectives:

By the end of the chapter the student should be able to:

(i) outline the importance of IT in operations management
(ii) discuss the various uses of IT in operations management

Introduction

Information and communication technologies (ICT) are one of the most important enablers of effective operations management. As electronic business gain importance, new opportunities exist, and the wide spread use of internet is increasing the interest for the information technologies. ICT tools are a source of competitive power for many companies. operations management, time and opportunities to get information on time is very important. Accurate and timely information will enable the organization to increase service level and as a result decrease the costs and lead times Along with this, many companies are offering information technologies based services to their customers in order to gain competitive edge and sustain long term relationships with them. Firms utilize ICT in the following ways in operations management:

Uses of IT in operations management

Machining centers: they not only provide automatic control of a machine but carry out automatic tooling changes as well. For example, a single machine may be equipped with a shuttle system of two worktables that can be rolled into and out of the machine. While work is being done at one table, the next part is mounted on the second table. When machining on the first table is complete, it is moved out of the way and the second part is moved into position.

Numerically controlled (NC) machines: these are under the control of a digital computer. Feedback control loops determine the position of the machine tooling during the work, constantly compare the actual location with the programmed location, and correct as needed.This eliminates time lost during setups, and applies to both high-volume, standardized types of products as well as low-volume, customized products.

Industrial robots: these are substitutes for human manipulation and other highly repetitive functions. A robot is a reprogrammable machine with multiple functions that can move devices through specialized motions to perform any number of tasks. It is essentially a mechanized arm that can be fitted with a variety of handlike fingers or grippers, vacuum cups, or a tool such as a wrench. Robots are capable of performing many factory operations ranging from machining processes to simple assembly

Computer-aided design and manufacturing (CAD/CAM): uses a computer to integrate component design and processing instructions. In current CAD/CAM systems, when the design is finalized, the link to CAM is made by producing the manufacturing instructions. Because of the efficiency of CAD/CAM systems, design and manufacture of small lots can be both fast and low in cost. Even though CAD/CAM systems are usually limited to larger companies because of the high initial cost, they do increase productivity and quality dramatically. More alternative designs can be produced, and the specifications can be more exact. Updates can be more readily made, and cost estimates more easily drawn. In addition, computer-aided process planning (CAPP) can shorten and, in some cases, even eliminate traditional process planning.

Flexible manufacturing system (FMS): Actually refers to a number of systems that differ in the degree of mechanization, automated transfer, and computer control and are sufficiently flexible to produce a wide variety of products. A flexible manufacturing module is a numerically controlled (NC) machine supported with a parts inventory, a tool changer, and a pallet changer. A flexible manufacturing cell consists of several flexible manufacturing modules organized according to the particular product's requirements. A flexible manufacturing group is a combination of flexible manufacturing modules and cells located in the same manufacturing area and joined by a materials handling system, such as an automated guided vehicle (AGV). A flexible production system consists of flexible manufacturing groups that connect different manufacturing areas, such as fabrication, machining, and assembly. A flexible manufacturing line is a series of dedicated machines connected by AGVs, robots, conveyors, or some other type of automated transfer device.

Computer-integrated manufacturing (CIM): this approach integrates all aspects of production into one automated system. Design, testing, fabrication, assembly, inspection, and materials handling may all have automated functions within the area. However, in most companies, communication between departments still flows by means of paperwork. In CIM, these islands of automation are integrated, thus eliminating the need for the paperwork. A computer links all sectors together, resulting in more efficiency, less paperwork, and less personnel expense.

Islands of automation: Refer to the transition from conventional manufacturing to the automated factory. Typical islands of automation include numerically controlled machine tools, robots, automated storage/retrieval systems, and machining centers.

Bar-coding: abar-code is a readable representation of information by a computer. Originally, information on barcodes was stored in the widths and spacing of written parallel lines, but nowadays, they come in different patterns of dots, concentric circles, and text codes. Barcodes can be read by optical scanners called barcode readers or scanner. Barcodes are widely used to implement automatic data capture systems that improve the speed and accuracy of computer data entry. Bar-coding accelerates the flow of products and information throughout the business. Barcoding may be used in counting raw materials and finished goods inventories,automatic sorting of cartons and bins on conveyor belts and palletizers, production reporting,automatic warehouse applications, including receiving, put away picking and shipping, package tracking, access control and lot tracking.

Radio Frequency Identification (RFID): An RFID tag contains a silicon chip that carries an identification number and an antenna able to transmit the number to a reading device. This means improved inventory management and replenishment and replenishment practices, which in turn, result in a reduction of interrupted production or lost sales due to being out of stock. RFID enables bulk read where many tags can be read in a short space of time a typical read rate is hundreds of tags per second, the tags can be read over a very long range many hundreds of metres in the case of specialized tags. RFID tags are durable because they can be ripped,

soiled and performance is not impaired. They can do bulk reading in a short space of time. All these importance enhance performance.

Enterprise Resource Planning (ERP): ERP is a business management system that, supported by multi-module application software that incorporates all departments or functions of the organization. While MRP allows manufacturers to track supplies, work-in-progress and the output of finished goods to meet sales order, ERP is applicable to all organizations and allow managers from all functions or departments to have an understanding of what is or is not taking place throughout the organization. Most of ERP systems are designed around a number of modules, each of which can be standalone or combined with others. The modules in the ERP system are finance, marketing, procurement, manufacturing, supplier management and human resource among other modules. ERP system plays a vital role in improving performance. There is faster inventory turnover because the manufacturers and distributors may increase inventory turns reduce inventory costs. There is improved customer service, in many cases, and ERP system can increase the production to a higher rate by
providing the required products at the required place within the required time thus achieving customer expectation and satisfaction. ERP facilitates better inventory accuracy with
fewer audits thus, reducing the need for physical audits. It also reduces the set-up time by ensuring coordination of people, tools and machinery together with efficient use of equipment and minimizing downtime by virtue of efficient maintenance. ERP software leads to high quality work with strong manufacturing components, proactively pinpoints quality issues, providing the information required to increase production levels reduce wastes or rework

Material Resource planning (MRP): This is a technique that assists in the detailed planning of production and its characteristics are that; it is geared specifically to assembly operations, it is a dependent demand technique and it is a computer based information system. The aim of MRP is to make available either purchased or company manufacturing assemblies just before they are required by the next stage of production or for delivery. It enables orders to be
tracked throughout the entire manufacturing process and assist purchasing and control departments to move the right supplies at the right time to manufacturing or distribution points

Distribution Requirements Planning (DRP): Distribution requirements planning (DRP) is scheduling technique the controls inventory control and applies MRP principles to distribution inventories It can also be considered as a method of handling replenishment of the stock in an organization. DRP is useful for both manufacturing organizations, such as car manufactures that sell their car via several distribution points, such as regional and local distributors, and purely merchandising organizations, such as supermarkets

Review questions

(i) outline the importance of IT in operations management
(ii) describe the main uses of IT in operations management

References

Ohno, T. 1988 *Toyota Production System: Beyond Large-Scale Production*, Productivity Press.

Russell, R.S & Taylor, B.W 2009, *Operations Management: Along the Supply Chain*, 6th edn, John Wiley & Sons Ltd, New York.

Shingo, S 1989, *A Study of Toyota Production System*, Productivity Press.

Slack, N; Chambers, S; Johnston, R 2010, *Operations Management*, 6th edn, Pearson Education Limited, Harlow.

Sample examination paper one
Instructions: attempt question one and any other two questions

Time allowed: 2 hours

Question one

(a) Define the term operations management (2 marks)
(b) List the five objectives of operations management (5marks)
(c) Distinguish between facility location and facility layout (4marks)
(d) Briefly discuss the product design process (8 marks)
(e) Highlight four types of inventory (4marks)
(f) Outline four types of quality costs (4 marks)
(g) Outline the key elements of lean operations (3 marks) **Total 30 marks**

Question two

(a) Outline five benefits of production planning and control (5 marks)
(b) Outline the activities involved in the production planning process (10 marks)
(c) Outline five activities in the dispatching phase of production control requiring authorization before being undertaken (5 marks)

Question three

(a) Identify the steps involved in the benchmarking process (10 marks)
(b) Highlight five guidelines to effective benchmarking and achievement of world class operations (10 marks)

Question four

(a) Outline five types of failure (10 marks)
(b) Explain the mechanisms used to detect failure in operations (10 marks)

Question five

Discuss the role of information technology in current operation management practice (20marks)

Sample examination paper two
Instructions: attempt question one and any other two questions

Time allowed: 2 hrs

Question one

(a) Highlight five differences between service operations and manufacturing operations (6 marks)
(b) Distinguish between product layout and process layout (4 marks)
(c) Distinguish between batch and jobbing production (4 marks)
(d) Outline five characteristics of supply and demand networks (5 marks)
(e) Define the term failure (2 marks)
(f) List five benefits of incorporating Information technology into operations management (5 marks)
(g) Distinguish between internal and external failure costs in relation to quality (3 marks)
(h) Define the term project (1 mark) **Total 30 marks**

Question two

(a) List the contribution of purchasing to product design and development (12 marks)
(b) Explain the benefits of involving the purchasing function in product design and development (8 marks)

Question three

Discuss the steps involved in undertaking the following activities

(a) Methods analysis (6marks)
(b) Time study (7 marks)
(c) Work sampling (5 marks)

Question four

(a) Outline four objectives of asset maintenance (8marks)
(b) Highlight seven components of an asset management plan (7 marks)
(c) Outline the approaches to asset maintenance (5 marks)

Question five

(a) Identify five areas emphasized by TQM (10 marks)
(b) Identify two techniques used to improve quality in TQM (10 marks)