CHAPTER THREE

PRODUCT DESIGN AND PROCESS SELECTION

3.1. Introduction

The essence of any organization is the products or services it offers. There is an obvious link between the design of those products or services and the success of the organization that have well-designed products or services. Firms that have well-designed products or services are more likely to realize their goals than those with poorly designed products or services. Hence, organizations have a vital stake in a good product and service design. This unit presents the major aspects of product and services design and how the process to produce them is designed and selected. Product and service design plays a strategic role in the degree to which an organization is able to achieve its goals. It is a major factor in customer satisfaction, product and service quality, and production costs (price). Because product design is concerned with the functional (use) and aesthetic requirements necessary to meet the demands of the market place and at the sometime achieve an acceptable rate of return. Decisions related to product designs have far reaching effect on the future of an organization. Therefore, great care must be taken while designing a product/service.

The objectives of product and service design may vary from situation to situation. Generally, however, the objectives/reasons are:

1. To introduce new or revised products or service to the market as quickly as possible;
2. To design product or service that have customer appeal;
3. To increase the level of customer satisfaction;
4. To reduce costs and;
5. To increase quality

In a competitive environment getting new or improved products or services to the market a head of competitors gives an organization a competitive advantage that can lead to increased profits as well increased market share and can create an image of the organization as a leader.

3.2. Factors affecting product Design

Decision pertaining to the final product design will influence or determine; the firm‟s image profitability, opportunities and the problems it may face in the future.

The product chosen for the firm‟s market will also determine:

- The need for capital
- The size and composition of the organizational structure
- The type of quantity of processing equipment’s
- The type quantity and quality of material and supply used
- The size and skill requirements of its work force.

Product design can require the input of different functional managers. The following discussion will help you to understand the decisions and roles of the different managers pertaining to product design.

1. Product design – a production manager's viewpoint

The production manager makes decision concerning process employed, quality, quantity, and type of materials that will go into it and the required supervision.

2. Product design - a marketing viewpoint

Marketing‟s optimal product design would be an innovative product that leads to high volume of sales, complements the firm‟s general product line, enhance the firms image in the market place, and available in any desired quantities at an attractive cost.

3. Product design – A Financial manager's view point

The concern of financial manager is to have a product that help to achieve the maximum return on investment, maintain the firm‟s financial liquidity and assures its survival. The strategic choice of a design becomes an important decision, which will materially affect the firm‟s profitability, growth and survival.

4. Product design – a top management view point.

The product decision represents one of the major decision top managers must make. However top managers must make a careful analysis and evaluation of the firm‟s strengths, weaknesses, interests, financial strength, managerial abilities and environment and numerous other factors prior to making the final product design decision

5. Product design- Quality Control View Point

Quality control, and indirect cost, will often be greatly affected by the product design choice. Designs will increase both production and quality control cost, if they are difficult to manufacture and require close process monitoring and numerous quality control checks to determine whether the product is in conformance with product specifications. These higher costs may come from a combination of higher reject and rework levels and high quality control costs, primarily from inspection.

3.3. The structure/ process of product design

Dear student! Are you interested to know about the process of product design? If you are it is stated as follows: The three major functions involved in product and service design are marketing, product development and manufacturing. Marketing has the responsibility for suggesting ideas for new product and for providing product specification for existing product lines. Product development has the responsibility for moving the technical concept for the product to its final design and manufacturing/operation function has the responsibility for selecting and/or configuring the process by which the product is to be manufactured.

The product development activity provides the link between the customer needs and expectations and the activity required to manufacturing the product. This will take you to the discussion of new product design processes.

The design process begins with motivation for design. For a new business or a new product, the motivation may be obvious to achieve the goals of the organization and realize new opportunities. However, making them happen /utilized them is a demanding challenge. New product development entails a complex set of activities that cut across most functions in business.

Product design research is the major source of product idea for most firms. It can be applied or basic. Product design research basically is search for ideas, information or relationships. If its purpose is the advancement of knowledge irrespective of short- term results, it is generally referred to as pure or basic research. The term "applied research" has Commercial overtones. Because it seeks to answer real or anticipated problems, applied research has short range objectives compared to those of basic research. Applied research projects includes the study of one‟s own product line for functional or aesthetic improvement, the analysis of competitor‟s product to determine how it was manufactured, the analysis of one's own manufacturing processes to improve output or reduce cost, and the analysis of the firm‟s organizational structure to increase efficiency. All of these research projects would be undertaken with the expectation of increasing profitability.

Innovation is an omnipresent in product development, the continual search for improvement takes place at each step or phase, from idea to finalize design. Design improvements may include a new product shape, color or texture while processing improvement may include that make a product or service economically attractive by increasing process efficiency, eliminating the number of conversion steps required or change packaging needs.

Step 2 Preliminary product design evaluation /Initial feasibility analysis/

In this stage of the product design process responsible personnel are involved in screening and evaluation of the product idea and they should:

- ensure that there is market potential or suffices demand
- ensure that the product can be produced with the existing resources and/or check what additional resources are required
- check financial feasibility implications by estimating the approximate cost and return or investment
- Finally, it may be necessary to consider the product is appropriate as to the company‟s policy and fulfills legal and environmental requirements.

Step 3 Product development and prototype stage.

The process of converting a set of ideas and invention, or a new product concept into the final form for manufacturing is called product development. The specification for material, processing tolerance, functional performance, maintainability, structural shape, reliability and appearance

There are also specific external factors to consider, such as government regulations, competitive pressures, customer needs, the appearance of new technologies etc. Ultimately, the customer is the challenging force for product and service design.

Product or service design follows seven consecutive steps. They are briefly explained as follows.

Step 1 Idea/concept stage

For product design and development, the starting point is product idea. It comes form a variety of sources. The most obvious source is the customer. Marketing can tape this source of ideas in a number of ways such as the use of focus groups, surveys, and the analyses of buying pattern. Other sources of idea include:

- concept or creation of an inventor
- A product already conceived and available from outside the firm.
- the results of individual designers or design teams employed by the firms for that specific purpose(employees)
- research and development department (R&D)
- distribution channel members
- Government agencies such as patent and copyright office
- Competitors or
- Any combination of the above sources

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- It demonstrates the functional requirements or its manufacturing feasibility.
- It illustrates or demonstrates some aesthetic or style requirements.
- It allows a firm to determine the need for specific processes or equipment to produce the products;
- Determine the functional reliability, ship ability, reparability, and packaging requirement of the proposed product,
- The probable sequence of manufacturing steps
- The feasibility of using standard parts,
- The identification of assembly problems and
- The need for and feasibility of refinement of design features.

Step 4 Economic Evaluation of the design

Designers should develop criteria for evaluation of alternative designs. The following are the four commonly used criteria

- Product performance /how well the product meets customer needs and requirements
- Development speed /how long it takes to get the product to market.
- Product cost/ the total cost to the customer/including manufacturing cost and
- Development program expense /one time development costs for the development project

Step 5 Preparation of product design specification.

The fundamental structure of the production process to be employed in producing a product is determined largely by the design specifications that are defined is blue prints, drawings, diagrams and material lists. These describe in detail the required dimensions, tolerances, finishes and materials of the parts or product.

Step 6. The pilot production Run

Small-scale production run or pilot production run is important for the following reasons. Some of these are:

1. If the product requires new technology or processes not commonly used by the firm, the output rate a process lay out envisioned may be less than that anticipated.
2. To reveal problems not anticipated or planned
3. To know yield, the percentage of acceptable product from a specific process step, may be less than what is required to match the output from another process step.
4. To provide a quantity of product for further studying market acceptance, developing better production, cost figures, evaluate labor and maintenance requirements, and determining reject levels more accurately.
5. To provide an opportunity to observe the manufacturing process more or less as they will occur if the decision for full-scale production is approved.
6. To reveal unidentified process problems, coordination requirements, needed quality control techniques difficulties in material handling and storage, and physical environmental factors such as noise or heat and other possible safety hazards.

A pilot run often employees scaled-down or modified equipment or use presently owned equipment or lease others. Some new product development programs do not include a pilot run if the product is similar to those already made or if the processes are very similar.

Step 7 Final product design selection decision

Few ideas will reach the final product selection stage. The process of searching ideas and evaluating their profit potential in light of the limits on the technological ability of the firm, the required financial investment, and the competitive and market conditions will eliminate all but a few when the design staff reaches this point, the final decision rests with top management.

Management based on their judgments, experience and additional information that point to better investment opportunities will accept or reject the design.

3.3.1. OTHER DESIGN CONSIDERATIONS

You might consider the following considerations in designing of a product.

1. Consumer Quality level. The design process should be aware of the market segment which the product is designed to serve and determine tolerance level with its cost implication. Four specific characteristics are related to quality in product design:

i. **Functionality.** It is the degree to which a product performs its intended functions /use/.
ii. **Maintainability.** Maintainability refers to the ease of performing maintenance on the product such as (lubricating, repairing hoses).
iii. **Reliability.** It is the ability of a product to perform as expected under normal conditions without excessive frequency of failure.
iv. **Reproducibility.** Refers to the ability of the production system to consistently produce products of the desired quality.

2. Standardization

Standardization is a means of achieve lower production and assembly costs through reducing variety. The choice of standardized parts is aimed at reducing unnecessary or economically unjustifiable variety in a group of products or parts.

Through standardization the hidden costs of unnecessary product controls; additional paper work, near duplicate designs; and the inefficient use of space, equipment, and tools can be reduced.

3. Value analysis and value engineering

Value analysis is a systematic organizational effort to reduce the costs of materials and purchased parts for producing a product, without sacrificing aesthetic or functional requirements, which is the (responsibility purchasing). Value engineering, closely related to value analysis, directs efforts at ensuring the functional ability of a product at minimum cost. It is the responsibility of engineering department.

4. Product Diversification and Simplification

Product diversification is the proliferation of product designs or an increase in the types, qualities, sizes, and colors of a particular product. There are economic reasons for caution in expanding product lines. These are:

- Smaller manufacturing runs
- Less efficient use of processes
- Higher labor, material, and set up costs.
- Higher level of inventory for the producer, distributor, and retailer.

Product Simplification on the other hand, is the elimination of the complex features of a product so that the intended function is performed but with reduced costs, higher quality and more custom satisfaction.

5. Modular Design /use of modules/ standardized block/

It is used to identify basic functional or aesthetic requirements for one or a number of products and designs a standard part, component, or subassembly that will meet the specification requirement of all the products in which it will be used.

6. CAD and Robotics

Design and redesign capabilities of such technology computerized design /CAD/ allow specifications to be tested singly or as part of a system for aesthetic or functional analysis.

- Use of robots
- Repetitive assembly
- Loading and unloading machines

- Painting and welding operations

3.4. Process Planning and Process design

Process planning and design is the complete delineation and description of the specific steps in production. The design and redesign of products and the design or redesign of processes are interrelated. Process planning and selection also involves choice of technology and related issues and it has major implications for capacity planning, layout of facilities, equipment, and design of work systems. This relationship can be best understood by having a look at on the following figure.

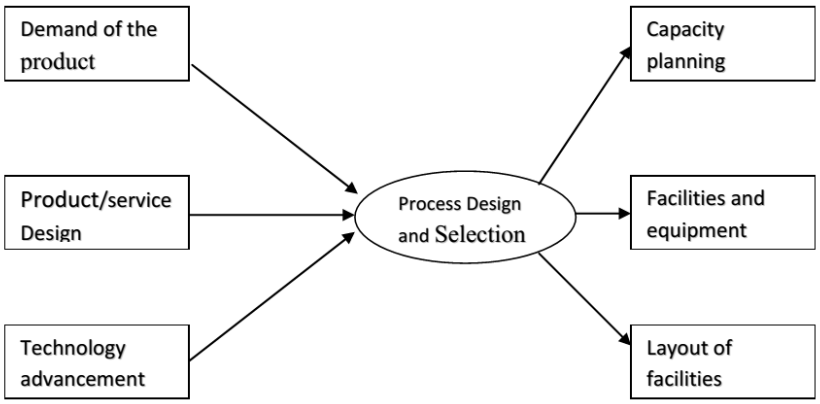


Fig. 3.1

Process selection occurs as a matter of course when new products or services are being planned. However, it also occurs periodically due to technological changes in equipment as well as changes in existing product or services.

3.4.1. Types of Processes

Can you identify the process type that we are going to follow in the development of a product?

At the basic level, the types of process can be categorized into three main categories:

1. Conversion Processes

Under this process the reaction under specific controlled conditions yields products that may hardly resemble their parents. For example, changing iron ore into steel sheets or making all the ingredients listed on the box of toothpaste into tooth paste are conversion processes.

2. Fabricating Processes

This process involves changing raw materials into some specific form. For example making sheet metal into car fender and making chair out of wood are fabricating processes.

3. Assembly processes

Assembly processes brings together necessary raw materials or components that makeup a product. For examples, assembly automobiles, building construction, house appliances etc.

3.4.2. Types of Process Design /process flow structure

Production system exists to produce product/ services of a kind that customers want and like a process flow structure refers to how a factory organizes material flow using one or more of the process technologies.

Major factors affecting choice of process designs decisions include:

1. **Nature of product demand pattern of demand and price-volume relationship**.

Production processes must have adequate capacity to produce the volume of the product that consumers want. Seasonality, growth trends, and other patterns of demand affect the amount of production capacity needed. /to meet quantities during peak demand seasons/.

Therefore, provisions must be made for expanding or contracting capacity to keep pace with the growth trends of sales.

Different types of production processes provide a different mix of competitive advantage therefore the choice of price and the choice of the design of production processes must be synchronized.

2. **Degree of Vertical Integration.**

Vertical integration is the amount of the production and distribution chain, from suppliers of components to the delivery of products to customers, that is brought under the ownership of accompany. There two types of vertical integration, that is forward and backward integration. Forward integration is expanding ownership of the production and distribution chain toward the market whereas, backward integration means expanding ownership of the production and distribution chain backward towards the source of supply. The degree to which a company decides to be vertically integrated determines now many production processes need to be planned and designed.

3. **Production flexibility.**

It refers to the ability to respond fast to customer's needs. Flexibility is of two types. The first is Product flexibility, which refers to the ability of the production system to quickly change from producing one product to producing another. For such cases, production process must be designed to include general-purpose equipment and cross trained employees. The second type of flexibility is volume flexibility. It is the ability to quickly increase or reduce the volume of products produced. Volume flexibility is needed when demand is subject to peaks and valleys and when it is impractical to inventory products in anticipation of customer demands. In this case production process must be designed with production capacities that can be quickly and inexpensively expanded and contracted. The fundamental nature of service creates the need for flexibility.

4. **Degree of Automation.**

Automation is the substitution of machinery for human labor. The machinery includes sensing, the control devices that enable it to operate automatically. A key question in process planning is whether to automate or not; and how much to automate, (fully or partially).

Advantages of Automation

Automation offers a number of advantages over human labor. Some of these are:

1. **It has low variability;** it is difficult for a human to perform as fast in exactly the same way, and in the same amount of time on a repetitive basis.
2. Machines do not get bored or distracted nor do they go out on strike, ask for higher wages, or file labor grievances.
3. It is taken as a necessary strategy for competitiveness.

Disadvantages/limitations

1. Automation can be costly because the acquisition of new technology can be expensive
2. Usually, it requires high volumes of output to offset high costs of initial investment.
3. Automation is much less flexible than human beings are.
4. Once process has been automated, there is substantial reason for not changing it
5. It often becomes an emotional issue with workers because of the fear of job loss.

For most services and for some manufacturers, customers are an active part of the process of producing and delivering products. The extent to which customers become involved in the production systems has important implications for the design of production processes. In this case every element of the equipment, employee training, and building must be designed with the customer in mind. Also, courteous attention, comfortable surrounding must be provided to receive, hold process and release customers.

At the other extreme of customer involvement, the design is little affected by interaction with customers.

3.4.3. Types of Process Flow Structure

There are basically, four (4) types of processing systems: continuous, assembly line, intermittent and project processing. These major operation processes are described briefly as follows:

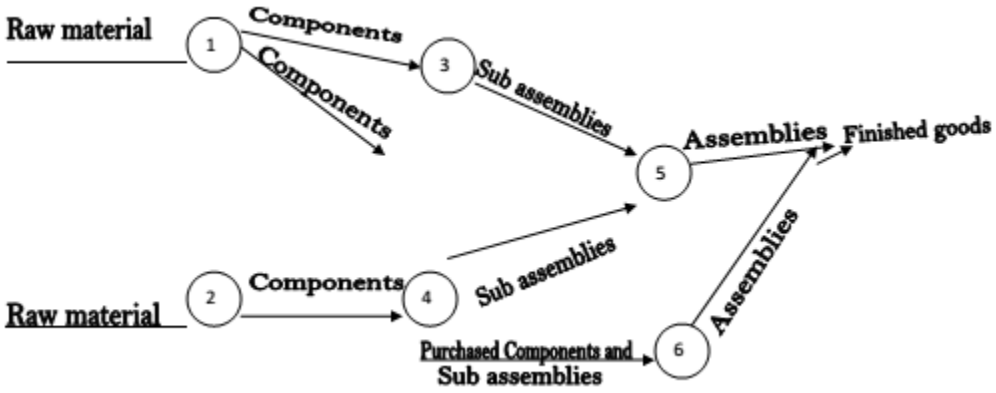
1. Continuous process (product-focused) form of production processing organization in which production departments are organized according to the type of product being produced. All of the production operation required to produce a product are ordinarily grouped in to one production department. It is also called line flow production or continuous production because; the product follows a pre-determined sequence of steps. In line flow production, products tend to follow along direct linear paths without backtracking or side tracking.

Continuous processing systems produce high volume of standardized output. The ultimate continues processing systems produce a single product such as flour, sugar, chemicals, liquid, powder, detergents, gasoline, oil, and the like. Generally, these products are measured on continues basis rather than counted as discrete units.

Characteristics of continuous or product-focused process

- The system produce highly uniform or standardized output
- Uses highly standardized machine/equipments and methods, and operated for 24 hours to avoid expensive shutdowns and startups.
- the skills requirements of workers are usually fairly low because of division of labor
- equipment tends to be highly specialized which tends to make it expensive relative to more general purpose equipment, but the high volume of output result in a low cost per unit
- product of such process are generally made for stock/inventory rather than customer order
- the process is inflexible, it handles only one product
- Product focused systems usually require high initial investment because it uses expensive, fixed-position material -handling equipment e.g. Overhead conveyors.

In continuous production products tend to proceed through production without stopping. This figure shows the flow of raw material from one end of production process to the other end following a straight line.



2. Assembly line process (Repetitive process)

Assembly line process refers to production of discrete parts moving from workstation to workstation at a controlled rate, following the sequence steps needed to build the product. This part of continuous process produces output that allows for some variety; products are highly similar but not identical. Examples include assembly of automobiles, televisions, computers calculators, cameras, appliances etc. Typically, these products are produced in discrete units. This form of processing is often referred to as repetitive manufacturing. The application of this process in service area is less common because services tend to be more customized on a per-unit basis. But still it can be applied in car washes, mechanical caressers, mail service, fast-food operations etc.

3. Intermittent Processing (Process-focused)

Intermittent processing is used when systems handle a variety of processing requirements on a start-and stop basis. This system is characterized by:

- A low volume of output than continuous process
- Use general-purpose equipment that can satisfy a variety of processing requirements.
- Require semiskilled or skilled workers who operate the general equipment
- The system is relatively flexible.
- Span of supervision is narrow than the low in the case of continuous process system.

Intermittent Processing takes two forms:

1. Batch Processing- Produces the same item again and again, usually in a specified lot sizes. Such system is generally employed when a business has a relatively stable line of products, each of which is produced in periodic batches, either to customers order or for inventory.

2. Job shop process- Used to handle/produce small batches/lots of a large number of different products most of which require a different set or sequence of processing steps.

Examples

- Commercial printing firms, publication
- airplane manufacturers
- Machine tool shops, Educational system

In job shops products do not follow continuous routes through production. On the contrary, the system is:

- highly irregular stop and go
- zigzag type routs with side tracking and backtracking
- Jobs spend the majority of this time waiting to be processed in production departments.

Process focused production systems include hospitals, automobile repair shop machine shop and manufacturing plants.

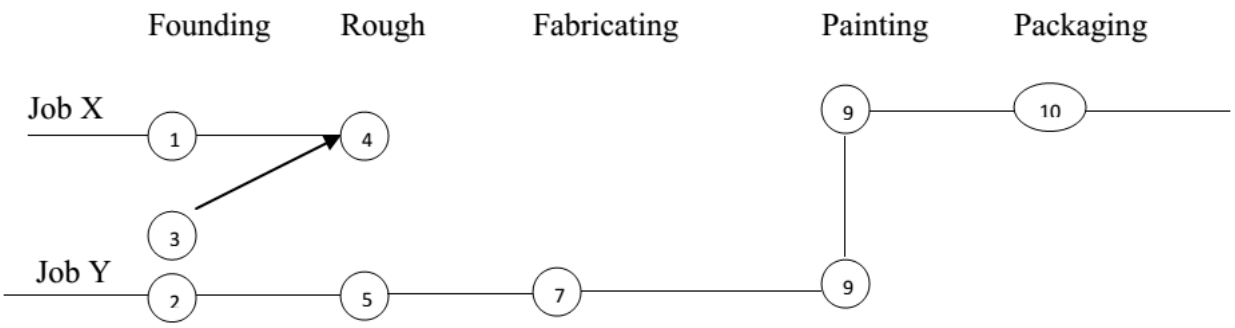
The advantages of job shop

- Product flexibility /able to produce small batches of a wide variety of products
- Less initial investment/they use general purpose equipment.

Problems

- greater employee skill
- more employee training
- more supervision

The following flow structure illustrates the process-focused production system.



What makes this system different from batch process is that the job requirements often vary considerably from job to job, so that the sequence of processing steps and the job content of the steps, vary considerably, for example, Auto repair shops.

Projects are set up to handle complex jobs consisting of unique sets of activities that must be completed in a limited time span. Examples of application include large or unusual construction projects, new product development or promotion and so on. This process in characterized by:

- high variable cost
- fixed costs are negligible or non-existent
- High skilled manpower-the process requires manpower who can work independently without much supervision and guidance.
- Involves the manufacture of a single, one-of-a kind product.

Processing Alternative decision

In deciding on a particular type of production processing organizations, several factors must be considered. Some these factors are:

1. Batch size and product variety. This factor includes the amount of product variety and the volume to be demanded of each product model

If the demand for a single product is high, product -focused is appropriate because cost/unit is very low but not flexible. Whereas, if products are many and one-of -kind job shop/ process focused is appropriate. Because this process flows structure allows companies to take the advantage of product flexibility.

2. Capital requirements for process Designs

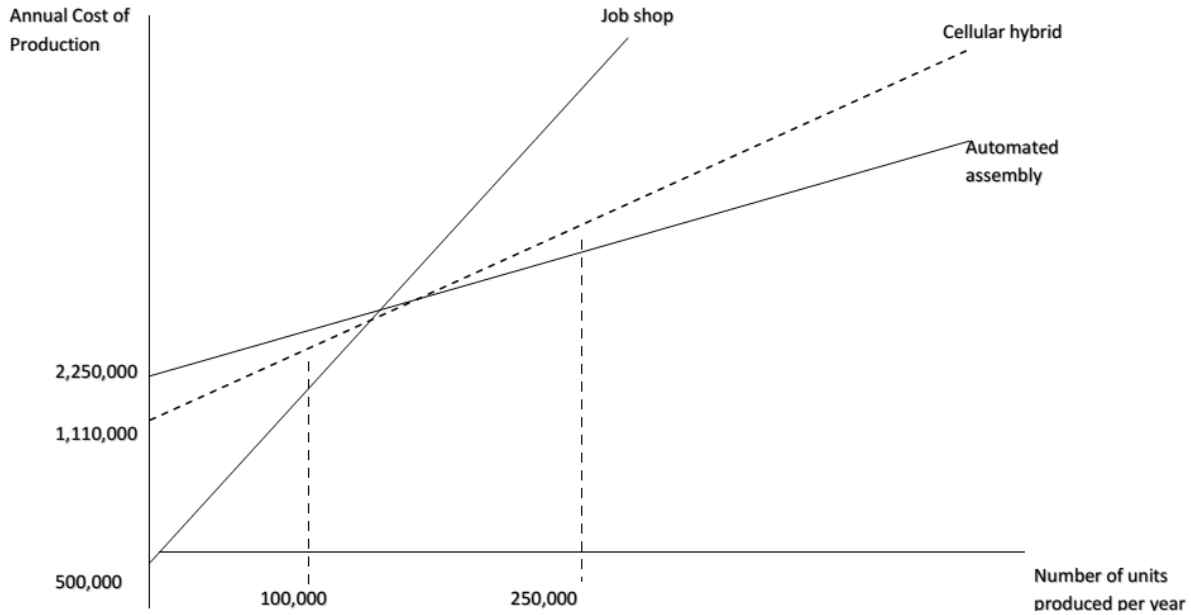
The second factor that affects the choice of production process is capital requirements for the process design. The amount of capital required for the production system tends to differ for each type of production processing organization. If a firm has only a little capital available for a particular product, process focused may be the only type of process design that can be planned.

3. Economic analysis

Commonly used to compare alternative processing plans for the production of products, four (4) important considerations include:

A. Cost function of processing alternatives. Each type of process design tends to require a different amount of capital. The greater that initial cost of equipment, buildings, and other fixed assets, the greater one the fixed costs. The cost function of a job shop usually exhibits very low fixed cost and very high variable costs.

If capital availability is not a factor and annual production costs are the predominate consideration, the process design that is preferred depends on the production volume of the product.



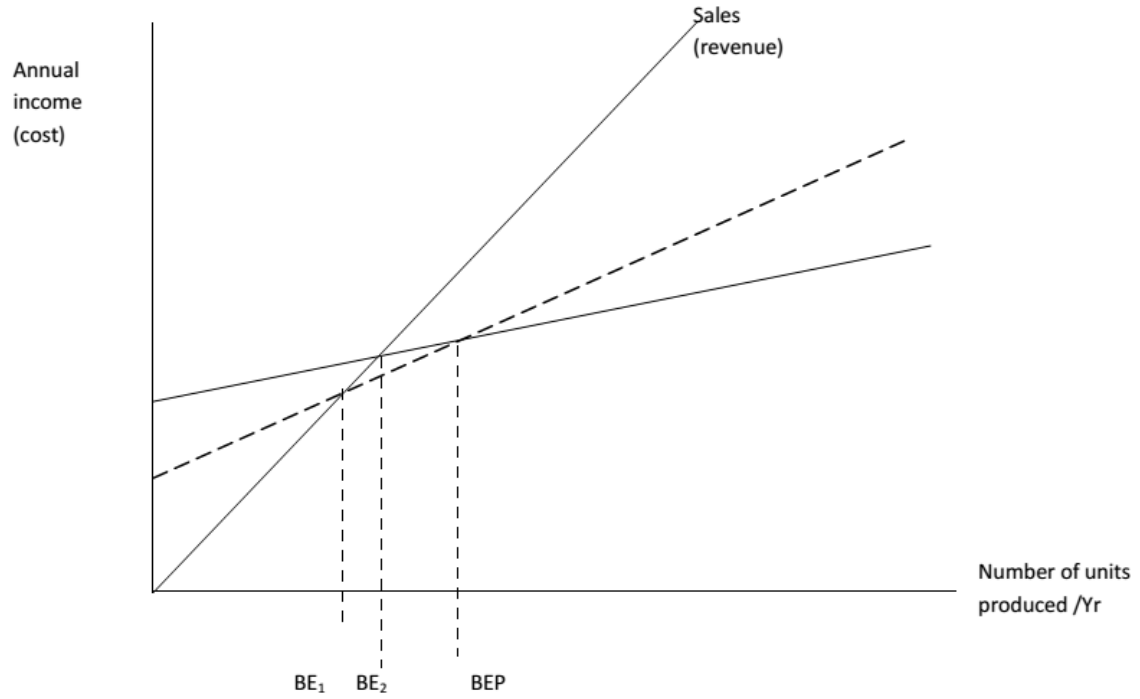
B. Concept of operating leverage. Operating leverage is a measure of the relationship between a firm's annual cost and its annual sales. If a high percentage of a firms total costs are fixed then the firm is said to have a high degree of operating leverage.

Other things being equal /held constant/, a high degree of operating leverage implies that a relatively small percentage change in sales will result in a large percentage change in operating income (the difference between annual sales and annual production costs).

The concept of operating leverage has the following important implications for the choice of process design.

1. Creator long rage profits can be realized from production processes with greater operating leverage once the production volume reaches a certain level.
2. Greater long-range losses can result from operation processes with greater operating leverage if the production volume is less than the breakeven point.
3. The high the operating leverage of a production process, the greater is uncertainty of future volume.
4. The great the uncertainty of sales forecasts, the great is the risk of losses using production processes with high operating leverage.

If there is a substantial amount of uncertainty concerning the forecast of number of products to be produced, process design with lower levels of operating leverage tend to be performed..



C. Break even Analysis (BEA)

Break Even Analysis (BEA) is commonly used to choose between processing alternatives. Itdoes have some weaknesses, however, when compared to other methods:

1. A primary weakness is the techniques inability to deal in a direct way with uncertainty. All of the costs, volumes and other information used in the technique must be assumed to be known with certainty.
2. The costs are assumed to hold over the entire range of possible volumes.
3. It does not take into account the time value of money.

Example: Three production processes, automated (A), Cellular(C) and job shop (J) have the following cost structure.

Process	Fixed cost per year	Variable cost per unit
A	110,000	2
C	80,000	4
T	75,000	5

a) What is the most economical process for a volume of 10,000 units per year?
b) At what volume would each of processes be preferred?

Solution

P = Price/unit Q = quantity produced and sold/period

V = Variable cost/unit P = Profit/period

Fc = Fixed cost/period TR = total revenue/period

TVC = Total Variable cost/period TC = Total cost/period

C = Contribution /period C = Contribution/unit

At BEP, profit is equal to zero (0)

$TR = PQ$ $FC = P.Q - V.Q = Q(P.V)$

$C = P_u - V_u$ $Q = {FC}/{(P - V)}$

$C = Q(Po - V) = TR - VQ = Fc + Pp$ $TVC = TR - FC = PQ - FC$

$TC = FC + TVC$

$TVC = VQ$

$P = TR - TC = PQ - (FC + VQ)$

$$Q = \frac{(P + Fc)}{Pu - Vu}$$

$$V = \frac{TR - TC}{Q} = \frac{PuQ - FC}{Q} = P - \frac{FC}{Q}$$

$$TR = FC + TVC = FC + VQ$$

$$P = \frac{(FC + VQ)}{Q} = \frac{FC}{Q} + Vv$$

a) TC = FC + V(Q)

TCA = FCA + VA(10,000)

= 110,000 + 2(10,000) = 130,000

TCc = FCc + Vc(10,000)

= 80,000 + 4(10,000) = 120,000

TCT = FCT + VT (10,000)

= 75,000 + 5(10,000) = 125,000

The cellular manufacturing production process has the lowest cost when Q = 10,000

b) TCJ = TCc

FCJ + VJ(Q) = FCc + Vc(Q)

75,000 + 5(Q) = 80,000 + 4(Q)

Q = 5,000 units

TCc = TCA

FCc + Vc(Q) = FCA + VA(Q)

80000 + 4(Q) = 110000 + 2(Q)

Q = 15000 units

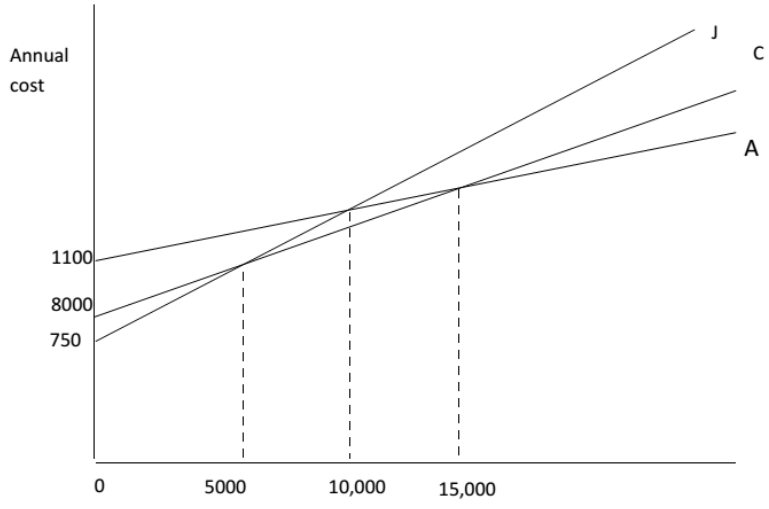


Fig. 3.4.

The job shop process would be preferred in the annual volume rate of 0 – 5000 units, cellular manufacturing in the 5000 – 15000 range and automated at 15000 or above

D. Financial Analysis

The great amount of money to be invested in production processing alternative and the length of time these assets are expected to last make the time value of money an important concept. The payback period, RPu, IRT and profitability under are aced to analyze POM problems involving long periods of time.

3.5. Service Design

Because of the difference between services and products, the design of services must take in to account different elements than the design of products. Consider these differences:

1. **Products are generally tangible;** service is generally intangible. Consequently, service design often focuses more on intangible factors such as peace of mind, ambiance than does product design.
2. **Series are often produced and received at the same time.** (e.g. Haircut, a car wash, repair etc), Because of this there is less latitude in finding and correcting errors before the customer has a chance to discover them. Consequently, training, process design; the customer relations are particularly important.
3. **Service cannot be inventoried.** This posse restriction on flexibility, and makes capacity design very important.
4. **Services are highly visible to customers, and must be designed with that in mind;** this adds an extra dimension to process design usually not present in product design
5. **Some services have low barriers to entry and exit.** This posse another burden on service design to continually be aware of what competitors are offering.
6. **Location is often important in-service design with convenience as a major factor.** Hence, design of services and choice of location are often closely linked.

Matching the Process and the Product

A key concept in process selection is the need to match market requirements with process capabilities. The distance between success and failure in production can sometimes be traced to choose of process. Products range from highly customized to highly standardize. Generally, volume requirements tend to increase as standardization increases; customized products tend to be low volume, and standardized products then to be high volume. These factors should be considered in determining the process to be used. This can be understood using a productprocess matrix given below.

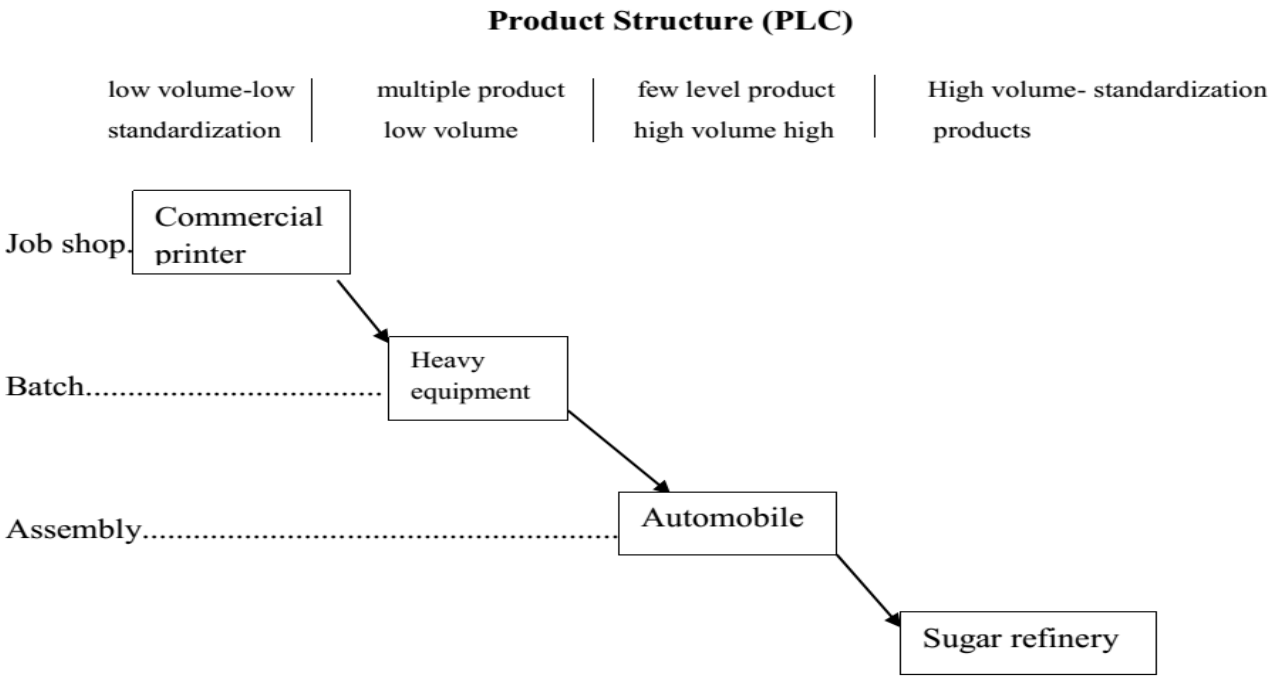


Table 3.1 summarizes the difference and similarities of the basic processes

Types of Production Processes	Product Volume	Product Variety	Automation & Specialized equipment	Frequency of machine set up & changes	Labor Skill	Unit Cost
1. Continuous	High	Low	High	Low	Low	Low
2. Assembly	Medium	medium	High	Low	Low	Low
3. Batch	Medium	medium	medium	Medium	Medium	Medium
4. Job Shop	Low	high	high	High	High	High
5. Project	Low	Low	Low	Low	High	High

3.6. Process flow Design

Process flow design focuses on the specific processes that raw materials, parts, and subassemblies follow as they move through the plant. The most common production management tools used in planning the process flow are:

1. Assembly drawings

2. Assembly Charts
3. Route Sheets
4. flow process Chart

Each of these charts is useful diagnostic tool and can be used to improve operations during the steady state of the productive system. Indeed, the standard first step in analyzing any production system is to map the flows and operations using one or more of these techniques. These are the "organizations charts" of the manufacturing system.

Assembly Drawing- is an exploded view of the product showing its component parts. The relative location of components is drawn in relation to each other to show how to assemble the unit.

Assembly Chart: - Uses the information presented in the assembly drawing and defines how parts go together their order of assembly, and often the overall managerial flow pattern. It lists all major materials, operations, inspection etc.

Operation and route sheet: - As its name implies, it specifies operations and processes routing for a particular part. It conveys such information as the type of equipment, tooling, and operations required to complete the part.

3.7. CAPACITY PLANNING, PLANT LAYOUT AND LOCATION ANALYSIS

How much should a plant be able to produce, where should it be located? Are important strategic question that must be addressed when a firm is starting out, when it expands and when it contracts because these decisions have long-term consequences for the organization. In this unit, you will examine capacity planning, location analysis and layout of facilities.

3.7.2. Capacity Planning

This is the concept of capacity planning. Capacity can be defined as ability to produce certain output within a specified time period or the rate of output that can be achieved from a process. Capacity is related to the equipment and process selection decision in that a selection of specific equipment and processes represents a selection of both technological flexibility and capacity. Capacity is also a product design specification. Decisions related to capacity have to answer:

a. How much capacity do we have and how much future capacity should we provide (process)
b. What form should capacity take?
c. How should people or processes be physically related to one another within the facility?
d. What is the optimal location for the facilities

3.7.2.1. Important Concepts of Capacity Decisions

A. Design Capacity

The design capacity represents the maximum output that can be achieved in a specific time period under ideal condition. Design capacity values are stared by the manufacturer of the equipment. It may and commonly does include recognition of the need for routine maintenance but does not include recognition of delays caused by factors like scheduling, conflicts, defective products, low quality material, or change in product mix. In other words, manufacturers cannot anticipate the actual conditions of use. Therefore, this level of capacity cannot to be achieved under the real situation.

B. Effective Capacity

Effective capacity represents the maximum output per unit time given a particular product mix, labor skills, supervision, product quality level, material quality, available maintenance, and time between setups. Effective capacity is rarely equivalent to design capacity and is frequently much lower.

C. Actual or Operating Capacity

Operating capacity is defined as the average output per unit of time over a preceding time period adjusted to reflect actual reject levels and scheduling and maintenance losses.

D. Capacity Measures

Though, there is no single measure of capacity, the two measures frequently cited to justify investments in equipment and processes are:

1) Efficiency and
2) Utilization

Efficiency is a measure of the use of effective capacity in producing a particular result. It is given by the formula:

$$\text{Efficiency} = \frac{\text{actual output per time period}}{\text{Effective capacity per time period}}$$

Utilization is a measure relating design capacity to output. It is calculated as follows:

$$\text{Utilization} = \frac{\text{actual output per time period}}{\text{Design capacity per time period}}$$

These measures will be modified for service industries. It tells you the degree to which the resources that is, machine, labor etc. are utilized.

Factors Influencing Effective Capacity

Effective capacity determines upper limit for actual capacity, which inurn determines actual output. Narrowing the difference between design capacity and effective capacity is a managerial opportunity because it may result in lower total investment.

Low effective capacity may indicate poor management practice, inadequate supervision, poor equipment choice, obsolete equipment etc. The major factors affecting effective capacity are the following.

a) Product Design

Product design affects capacity by determining the total work content or processing requirements for producing a product changes in design or a greater variety of products will generally affect capacity adversely by requiring more frequent changes in setups, rework, and solution.

- simplify product design
- changes infrequent
- Long production run

b) Layout of facilities -It affects on the flow of materials in the process production and the effectiveness of labor.

c) Job design – by establishing a lower time limit for operator controlled jobs.

d) Output standards: Differences in expected performance speeds and allowances for such necessities as personal time and fatigue alter effective capacity. This is four both operator controlled and mechanic controlled jobs.

e) The quality of and variation in the materials used by altering the number of process adjustment required, scrap and rework and material quality as well as by the number of setups required.

f) Employee attitude and motivation through labor turnover, absenteeism, and employees being busy but not productive.

g) Operational factors. Inventory stocking decisions, late deliveries, acceptability of purchased materials, and quality of inspection and control procedures also can have an impact on effective capacity.

h) External factors. Product standards, especially minimum quality and performance standards, and government regulation can restrict management's option for increasing and using capacity. Thus, pollution standards on products and equipment often reduce effective capacity, as does paper work require by engaging employees in non-productive activities. A similar effect occurs when a union contract limits the member of hours and type of work an employee may do.

2.7.2.2. Capacity and Level of Operation

The best operating level is the level of capacity for which the average unit cost is at a minimum. This level of operation is shown in the figure below:

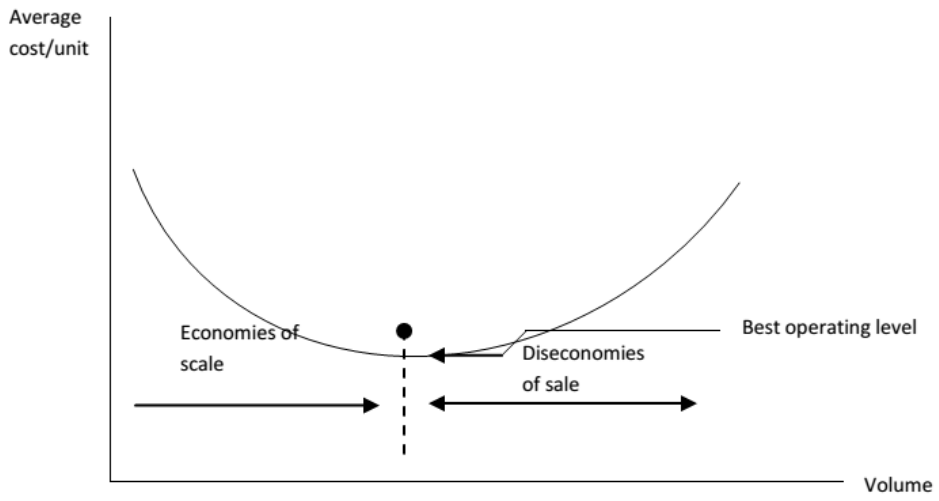


Fig. 3.5.

As we move down the curve, we achieve economies of scale until we reach the best operating level and we encounter diseconomies of scale as we exceed this point. The upward swing of unit cost as volume increases results from:

- using less efficient machines
- working overtimes
- increasing the cost of maintenance or
- using inexperience or less skilled employees

Capacity planning decisions

Capacity planning normally involves the following steps.

1. Assessing existing capacity
2. Forecasting capacity needs
3. Identifying alternative ways to modify capacity
4. Evaluating financial, economical and technological capacity alternatives.
5. Selecting a capacity alternative most suited to achieving strategic mission.

Following these steps, organization should design the right capacity, that is, the capacity best matches with the demands of the product. However, there are several reasons why the production capacity to be provided does not necessarily equal the amount of products and services expected to be demanded. First enough capital and other resources may not be economically available to satisfy all of the demand. Secondly, because of the uncertainty of forecasts and the need to link production capacity to operations strategy interns of competitive priorities, a capacity cushion may be provided. A capacity cushion is an additional amount of production capacity added onto the expected demand to allow;

1. Extra capacity incases more demand than expected occurs
2. The ability to satisfy demand during peak demand seasons.

3. Lower production costs; production facilities operated to close to capacity experience higher costs.
4. Product and volume flexibility responding to customers‟ needs for different products and high volumes is possible because of the extra capacity.
5. Improved quality of products and services; production facilities operated close to capacity experience deteriorating quality.

Ways of changing long range capacity

A. Expansion would take either or a combination of the ways;

- Sub-contract with other companies to become suppliers of the expanding firm‟s components or entire products.
- Acquire other companies, facilities or resources
- Develop sites, build buildings, by equipment
- Expand, update, or modify existing facilities or
- Reactivate facilities on standby status

B. Reduction This strategy requires managers to take the following actions when expansion is not appropriate due low demand or any other internal and external factors.

- Sell of existing facilities; sell inventories, and layoff or transfer employees.
- Mothball facilities and standby status, sell inventories, and layoff or transfer employees.
- Develop and produce new products as other products decline.

Evaluating Capacity Alternatives

An organization needs to examine alternatives for future capacity from a number of different perspectives. Most obvious are economic considerations. Such as; will an alternative be economically feasible? How much will it cost? How soon can we have it? What will the operating and maintenance costs be? What will its useful life be? Will it be compatible with present personnel and present operations?

A number of techniques are useful for evaluating capacity alternatives from an economic standpoint. Some of the more common are cost-volume analysis (Break-even analysis), financial analysis, decision theory, and waiting line analysis. Only cost volume analysis and decision tree are described in this unit.

1. Break-Even Analysis

Though different tactics can be used to adjust demand to existing facilities, the strategic issue is, of course, how to have facility of the correct size. Break-even analysis may help with that decision.

Breakeven can aid capacity decisions by identifying the processes with the lowest total cost for the volume expected. The objective of break-even analysis is to find the point, in dollars and units, at which cots equal revenues-which is the break-even point. Break-even analysis requires

an estimation of *fixed costs*, *variable cos*t, and *revenue*. Fixed costs are costs that continue even if no units are produced such as depreciation, taxes, debt and mortgage payments whereas variable costs are those that vary with the volume of units produced. The major components of variable costs are labor and materials and other costs such as the portion of the utilities that varies with volume. Another element in break-even analysis is the revenue function that begins at the origin and proceeds upward to the right increasing by the selling price of each unit. Where the revenue function crosses the total cost line is the break-even point, with a profit corridor to the right and a loss corridor to the left. Break-even analysis assumes that costs and revenue increase in direct proportion to the volume of units being produced. However, neither fixed costs nor variable costs (nor, for that matter, the revenue function) need be a straight line.

Example: XYZ Company is now contemplating to adding new line of product, which require leasing new machine for a monthly payment of Br. 6000. Variable costs would be Br.2.00 per unit, and the product would be sold for Br.7.00 each.

Required:

1. What should be the monthly production capacity of a machine for achieving a breakeven point?
2. What should be a production capacity so that a firm can achieve a profit target of Br. 4000?

Solution: 1. Given: Fixed cost (FC) = Br.6000

Variable cost per unit (V) = Br. 2.00

Price per unit (P) = Br.7.00

Breakeven point (Q) =?

At a breakeven point, a firm earns zero normal profit. That is total revenue equals total cost and hence profit becomes zero. Thus,

Total profit = total revenue (TR) – Total cost (TC)

Total profit = TR – TC

TR = P X Q

TC = Total variable cost (which is V x Q) + FC, hence

Total profit = (P X Q) – (V X Q + FC)

At break-even point total profit is zero. Thus,

0 = PQ – VQ – FC

0 = Q (P – V) – FC

FC = Q (P – V)

Q = FC/(P – V)

Q = FC / (p – v) = Br. 6000 / (7.00 – 2.00) = **1,200** units of pies per month.

In order to achieve the break-even goal a firm must lease a machine that has a monthly production capacity of 1,200 units..

2. Given:

Total profit = Br.4000

P = Br.7.00

V = Br.2.00

FC = Br. 6000

The quantity level required to achieve any profit level is obtained as follows:

Total profit (TP) = TR – TC

TP = PQ – VQ – FC

TP + FC = PQ – VQ

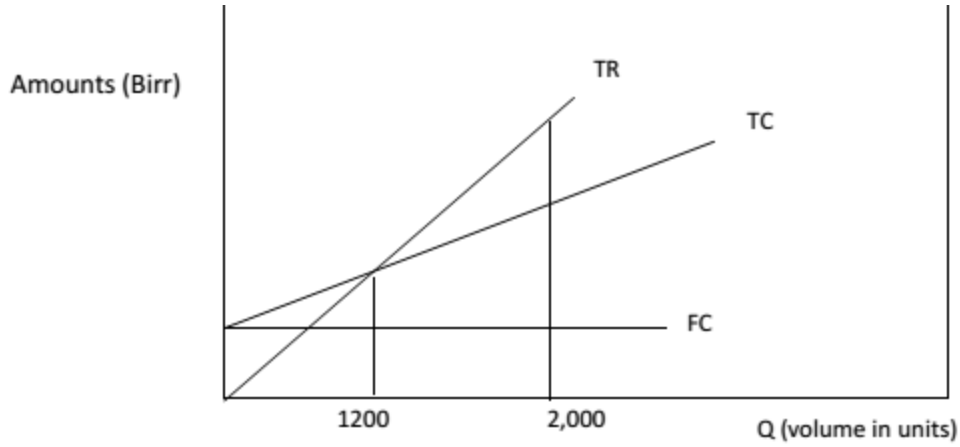
TP + FC = Q (P – C)

Q = (TP + FC) □ (P – V)

Q = (Br.4000 + Br.6000) □ (Br.7.00 – Br. 2.00) = 2,000 units.

To achieve this profit level per month, a firm must lease a machine with the monthly production capacity of 2,000 units.

Figure 3.6: depicts the example just presented above.



As a figure illustrates, total revenue and total curve crosses each other at the quantity level 1,200 units and that is a breakeven point. Once the quantity produced exceeds that level, a company starts to earn point and the size of profit increases with the quantity of output (production). As stated above, for this particular example a machine under consideration must have monthly production capacity of 2,000 units for a company to achieve the stated level of profit (Br.4,000). To utilize the concept of breakeven analysis for capacity planning decision, we first define out goal such as a profit level, and then work back to determine the size of facility to be owned so that its production capacity can effectively lead to the production level required (i.e., quantity) to achieve a goal.

2. Decision Tree

Decision tree is a tree like diagram that depicts alternatives and their possible outcomes. This tool can be used to evaluate alternative capacities and enable managers make appropriate decisions.

Example. A firm that plans to expand its product line must decide whether to build a small or a large facility to produce the new products. If it builds a small facility and demand is low, the net present value (NPV) after deducting for building costs will be Br. 400,000. If demand is high, the firm can either maintain the small facility or expand it. Expansion would have a net present value of Br. 450,000 and maintaining the small facility would have a net present value of Br. 50,000. If a large facility is build and demand is high, the estimated NPV is Br. 800,000. If demand turns out to be low, the NPV will be Br. 10,000.

The problem that demand will be high is estimated to be 0.60, and the problem of low demand is

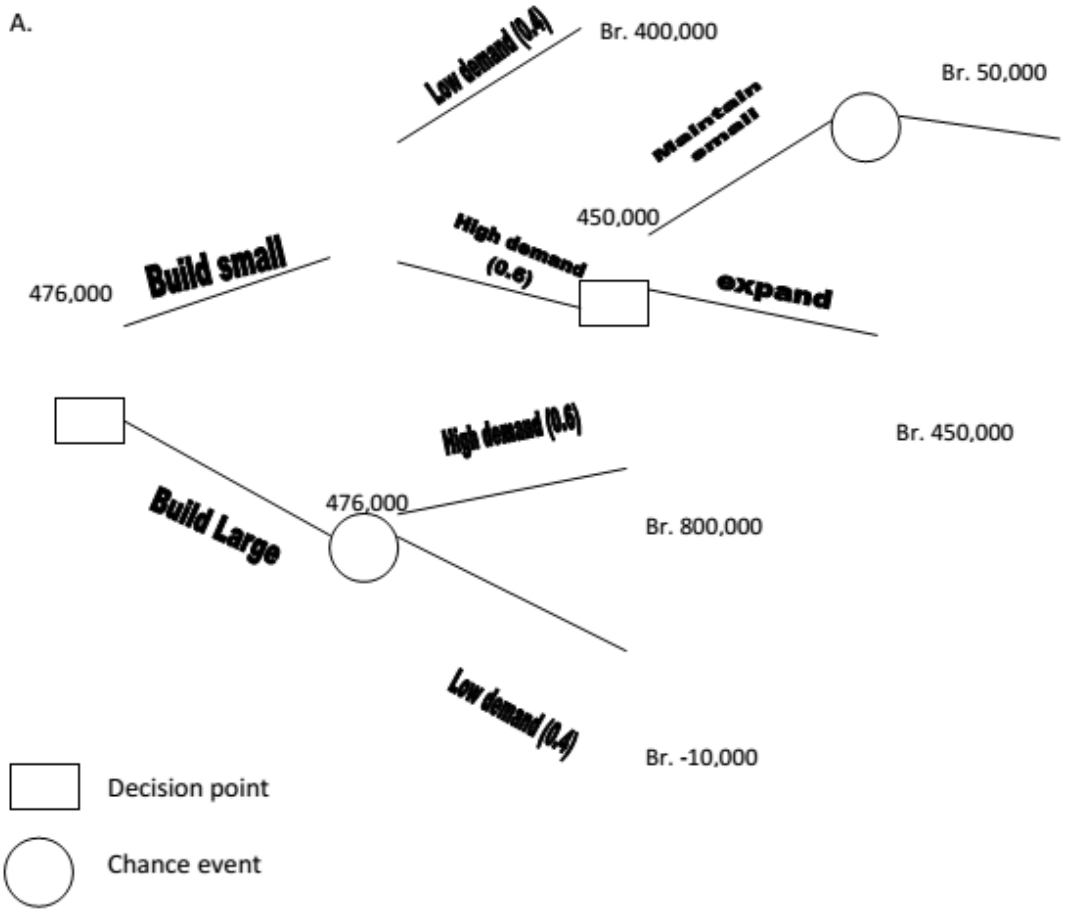
estimated to be 0.4.

Required:

a. Draw the tree diagram.
b. Which alternative capacity should be build? What is the expected NPV of the alternative chosen?

Solution:

A.



B. The expected NPV

i. Build small facility:

High demand = 0.6 x 450,000

= 270,000

Low demand = 0.4 x 400,000

= 160,000

Expected value = 270,000 + 160,000

= 430,000 Br

ii. Build large facility

High demand = 0.6 x 800,000

= 480,000

Low demand = 0.4 – 10,000

= -4,000

Expected value = 476,000 Br

Decision: The firm should build the large facility with the highest expected profit i.e., Br. 476,000.

3.8. Facility Layout

The general objective of facility layout is to locate people, machines, and processes in an optimal time-saving and money saving relationship that meets the anticipated production level and the products functional and aesthetic requirements as embodied in the design specification. Student! I think you are now familiar with the objective of facility layout.

Layout refers to the configuration of departments, work centers and equipment with a particular emphasis on movement of work through the system.

3.8.1. Objectives of Facility layout

The overall objective in designing a layout is to provide a smooth work flow and control; reducing cost of material through the factory or uncomplicated pattern for both consumers and workers in a service organization. Specific objectives of layout decision in service and manufacturing operations are outlined in the following section.

1. For manufacturing firm.

- Provide enough production capacity
- Minimize material handling cost and effort
- Minimize labor requirements
- Provide a smooth flow of materials and product

- Maximize the use of available space
- Provide for volume and product flexibility and avoid bottleneck operations and contested areas
- Minimize health hazards
- Maximize the uses of machine tools.
- Provide communication opportunities for employees by positioning equipment and processes appropriately
- Maximize output
- Minimize supervisory and control requirements
- Ease of maintenance
- Provide space for personal – care needs and others

2. For service operations layout serves the following purposes.

- provide for customer comfort and convenience
- allow attractive display
- reduce travel of personnel and customers
- provide for private in work areas
- promote communication
- Provide for stock rotation for shelf life.

3.8.2. Basic Types of Layouts

There are four basic types of plant or facility layouts. The basic difference among these layouts is in their handling of the flow of materials and product. They are discussed as follows.

1. Process layout /for job-shops/

It is concerned with the grouping of machines, processes or services according to their function i.e. similar equipment's or functions are grouped together. For example, Drilling, milling, routing, typing, shipping etc are activities that require such types of arrangements. The primary efficiency criterion for evaluating process layout designs is material and product handling cost.

Advantages

A. Process layouts are less vulnerable to breakdowns or absenteeism than other types of layouts since work can be shifted to other operating machines, and substitute for absent employees are more readily available because employees have multiple skills.
B. Lower capital costs use. Because this layout uses a general – purpose machines, which are less likely to become obsolete than special-purpose machines.
C. Lower labour costs /training and scheduling employees to operate more than one type of machine.
D. Lower installation and maintenance costs since excess capacity is often available.

Disadvantages

A. Work scheduling is complicated by the difficulty of determining process workloads, by the different processing sequence required for different products, and by bottleneck operations and conflicts in completion time requirements.
B. Low output rates result from material handling inefficiencies and from the number of special setups and fear downs necessitated by changes in the pattern of demand.
C. If the number of in-process products is large, process confession may result as efforts are made to meet schedule completion dates.
D. Material – handling requirements are a major problem because they are costly and time consuming. Conveyors are expensive to install and difficult to design since there may be many destinations for materials or products in process.

Materials used in manufacturing are many, some of these are: raw materials, purchased components, materials-in-process, finished goods, packing materials, maintenance and repair supplies, scrap and waste and rejects or reworks.

The layout of these facilities is directly affected by the nature /characteristics/ of materials such as: Large or bulky materials; heavy materials; solids; fluids or flexible and inflexible. Special materials for heat, cold, light, humidity, flame, vibration also will affect the layout of facilities for handling, storing, and processing of these materials.

2. Product or Line Layout

Product layout focuses on the sequence of production or assembly operation required for producing a part or a product of cement, oil refining, auto assembly and the so on. In contrast to process layouts, product layouts are not flexible since they are designed specifically for making one product.

Major Advantages

1. If there is adequate output volume, processing and assembly unit costs are low because of the high utilization rates of plant equipment and processes.
2. Raw materials and parts inventory control requirements are lower because inputs are required for only one product.
3. Production scheduling is simpler
4. High volume of output and high labour efficiency result when the sequential tasks performed require approximately the same amount of time.
5. Material – handling costs are low because of the wide use of conveyors and other mechanical or automated transfer equipment.
6. Supervisory and control costs are low because of the repetitive and routine nature of the tasks and the uniformity of the processing result.

Disadvantages

1. High volume is required to justify the large investment in special or modified equipment.
2. Product standardization is required with in close limits because of the inflexibility of specialized equipment and transfer mechanisms.
3. High interchangeability of product parts is required because the time and the space available to work on a given unit of production are limited.
4. Good maintenance is crucial since the failure of one piece of equipment requires stopping the entire line while it is being repaired.
5. Quality control inspection must be strategically located and must be capable of detecting undesirable variances. The inspection system must feed the information „upstream" efficiently to signal the need to correct processing or assembly failures and to prevent the production of a large volume of non-standard product.
6. Highly skilled behind-the-scenes labour is required for quick and efficient machine maintenance.

7. Scheduling and conditioning of materials, parts and subassemblies with line requirements is crucial because any bottleneck will result in products being incompletely fabricated or assembled or will require that the line be shut down.

3. Cellular Manufacturing (CM) Layouts'

Machines are grouped into cells and the cells function somewhat like a product layout is land within a larger shop or process this layout groups dissimilar machines into work centers (or cells) to work on products that have similar shapes and processing requirements. Since machines are frequency able to perform more than one operation on a particular part or product they take on some of the characteristics of a production line but without its rigidity and it is similar to process layout in that cells are designed to perform a specific set of processes. The reasons why a CM layout would be attempted are:

- Machine changeovers are simplified.
- Training periods for workers are shortened
- Material handling costs are reduced
- Parts can be made faster and shipped more quickly
- Less-in-process inventory is required
- Production is easier to automate

4. Fixed position Layout

Unlike the three other basic layout options, fixed position layouts require that both people and machine be brought to the product being made, assembled, or tested. The product by virtue of its bulk or weight remaining at one location, For example, Shipbuilding, dam construction, power generating (steam) turbines, bridge etc which are (bulky, large, heavy, and fragile). The fixed position nature of the layout minimizes the amount of product movement required.

Developing and Analyzing Facility Layouts

Important inputs to the layout decision are:

1. Specification of objectives of the system in terms of output and flexibility
2. Estimation of product or service demand on the system

3. Processing requirements in terms of number of operations and amount of flow between departments and work centers.
4. Space availability within the facility itself.

3.8.3. Facility Layout Techniques

There are four major layout techniques that can be used to make a layout decision. These are operations sequence analysis, block diagram analysis, systematic layout planning and load distance analysis. The following section describes these techniques.

1. Operations Sequence Analysis

This approach develops a good scheme for the arrangement of departments by graphically analyzing the layout problem. It determines the location of operating departments relative to one another when the external shape and dimensions of the building are not limiting factors.

To make a process layout of a plant or department we must have information on the movement of material within the plant and on the in-process goods moving from department to department, i.e., the number of moves and the cost of making these moves.

N.B. 1000 units of material being moved from location A to B at one time constitutes one move not 1000.

The following table shows the flow of materials and in process production for a period of months. The data represents all the firms‟ products whose fabrication or assembly requires some or all of the same process steps in the same sequence or a different sequence.

2. Block Diagram Analysis:

Block diagram analysis sets the general shape and dimensions of the building and the location of the interior departmental boundary.

3. Systematic Layout Planning (SLP)

In some production systems, such as service systems, the amount of material that flows between departments. May not be critical to developing a good facility layout. In these systems systematic layout planning can be used. The application of systematic layout planning (SLP) requires you to follow the following steps.

Step I: Develop a chart to rate the relative importance of each department being close to every other department. The rating range from the extremes of absolutely necessary to undesirable. The ratings are based on various reasons such as:

- types of customers
- ease of supervision
- common personnel
- Common equipment etc.

Step II: An initial schematic diagram, similar to the one is operation sequence analysis is developed. This initial schematic diagram is modified through trial and error until departments with high closeness ratings are adjacent to one another and department and space limitations are satisfied SLP is quite similar to operation sequence and block diagram analysis is both procedures and end results. The only significant difference between these approaches is that SLP allows many reasons for assigning a closeness rating between departments, whereas operation sequence and block diagram analyses allow a single reason product or material travel per time.

4. Load Distance Analysis

Load distance Analysis is useful in comparing alternative layouts to identify the one with the least product or material travel per time period.

follow the following steps.

1. Compute the total travel for each product through each layout alternative.
2. Compute the total distance traveled per month for each product through each layout alternative.
3. Choose the layout alternative that minimizes total travel distance. Based on the above analysis,

3.9. Facility Location

Choice of location for business organization is an important issue in the design of the production system.

This is a top question on the strategic agendas of contemporary manufacturing and service firms, particularly in this age of global markets and global production. Globalization allows companies

greater flexibility in their location choices. However, in practice, the question of location is very much linked to two competitive imperatives.

1. The need to produce close to the customer due to time based competition, trade agreements, and shipment costs.
2. The need to locate near the appropriate resource pool to take advantage of low costs.

Location decision is an integral part of the strategic planning process of every organization. Although it might appear that location decision are mostly one-time problem pertaining to new organization, the fact is that existing organization often have a bigger stake in these kinds of decisions than new organization. In other words, location problems are common to new and existing businesses.

The Need for location Decisions

Existing organization become involved in location decision for a variety of reasons; the following are some of the reasons for such decisions (other than the need for greater capacity).

1. Opportunity for expanding market share

From such as banks, fast food chains, supermarkets, and retail stores view location as part of marketing strategy, and they look for locations that will help them to expand their markets. Basically, the location decisions in those cases reflect additional new location to existing suppliers.

2. Business growth in demand

A similar situation occurs when an organization experiences a growth in demand for its products or service that cannot be satisfied by expansion at an existing location. The addition of a new location to complement an existing system is often a realistic alternative.

3. Depletion of Basic resources

Some firms become presented with location decision because of the depletion of basic inputs. For example, fishing and logging operations are forced to relocate due to the temporarily exhaustions of fish or forest at a given location. Mining and petroleum organization face the same sort of situation, although usually over a longer time horizon.

4. Shift in Market /demand

If the demand for the product does not exist in the existing location, it is a good reason to consider and find out a better location.

5. Operating Costs

Cost of doing business in a particular location reach, a point where other location begins to look more attractive. In this case, the company may shift to a cost-effective location.

6. Merge of companies

Merger of companies changes the ownership titles and may require change in management and operation of the merging firms, and then leading to location decisions.

7. Introduction of new product.

This may require to a new resource, labor or material which may not exist in the existing location. Therefore, firms make a location decision to produce a sell their new product.

Characteristics of location decision

1. Location decisions entail a long-term commitment, which makes mistakes difficult to overcome. In addition, location decision often has an impact on operating costs both fixed and variables and revenues as well as an operation. Example, a poor choice of location might result in excessive transportation cost, shortage of qualified labor, loss of competitive advantage, shortage of raw materials and location of customer (operation problem).
2. Location decision requires the selection of location form a number of acceptable location instead of identifying the “One best” location. If one site is clearly superior to all others in all respects, the location decision is an easy one. However, several site candidates, each with its strengths and weaknesses emerge as good choice and the location decision becomes a tradeoff decision.
3. Location decision involves four options that mangers can consider in location planning.

   These are:

A. Expanding an existing facility – These options can be attractive if there is adequate room for expansion, especially if the location has desirable features that are not readily available elsewhere. Expansion costs are often less than those of other alternatives.

B. Addition new location. Another option is to add new location while retaining existing ones, as it is done in many retail operations. The advantage of this option are: it draws /attracts customers who are already looking for an existing business, and used as a defensive strategy designed to maintain a market share or prevent competitors form entering a market.

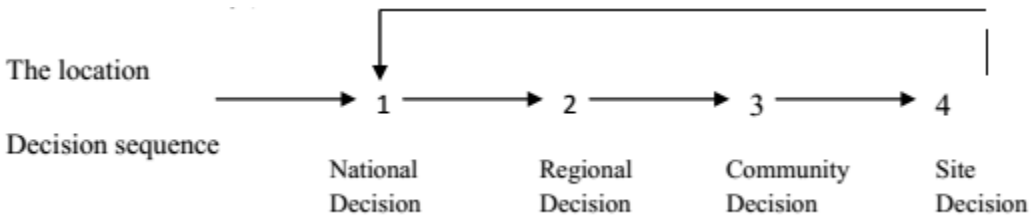
C. Shutting down. The third option is to shut down at one location and move to another. An organization must weigh the cost of a move and the resulting benefits against the costs and benefits and remaining in an existing location. This option is considered when market shifts, exhaustion of raw materials and the cost of operation often cause firms to seriously consider this option.

D. Doing nothing. If is a detailed analysis of potential locations fails to uncover benefits that make one of the previous three alternatives attractive, a firm may decide to maintain a status of at least for the time being

3.9.1. Factors Affecting Location Decisions

Many factors influence location decisions. Managers must identify the relevant factors to make decisions that involve a sequence of decisions. This sequence can include a national, a regional community and site decisions.

First management must decide whether the facility will be located internationally or domestically. (Where in the world political, military, social and economic instability can make such decision risky.)



Types of facilities and this dominant location factors; each type of facility under consideration has a few dominant factors that ultimately determine its location decision.

A. Mining, heavy manufacturing.

They are capital intensive, cover large geographic areas, use great quantities of heavy and bulky raw materials, population processes disead large amount of wastes, total finished outputs weight much less than raw material input, enormous utilities are absorbed and products are shipped to a few customers.

B. Light Manufacturing/Making electronic components, small mechanical parts, assembly etc.

- Do not necessary locate near either raw material or market.
- They ship products to a few regional warehouses of wholesalers
- Availability and cost of labor is important

C. Warehouses

Dominant factors are those affecting incoming and outgoing transportation cost retailing facilities

D. Retailing facilities

The studies involve the identification of target customer because it should be located near concentration of customers. Residential concentration, traffic data on nearby streets growth trends of communities and suburbs, spending level and other demographic information.

E. Facilities for customer service organizations such as dry cleaning, banks, hotels, welding shops, photo processors like retailing shops target this customers

- Can discharge large quantities of waste paper, chemical and spent supplies,

F. Local government service

- Often grouped together so that constituents can economize in their time, effort, and transportation cost
- Are grouped to allow interagency interactions

G. Health and emergency services (Fire station, ambulances, hospitals, etc)

- lowest overall response times between the constituent and the service
- Minimize property and loss of life
- The type of facility
- The number of its products and services
- The nature of its daily activities

The national, regional, community and side related factors are briefly all explained in the next section.

(A) Regional factors

1. Proximity to customers

A location close to the customer is important because of the ever increasing need to be customer responsive. This enables faster delivery of goods to customers. In addition, it ensures that customers‟ needs are incorporated into the products being developed and built.

2. Business Climate.

A favorable business climate can include the presence of similar sized business, the presence of companies in the same industry, and in the case of international location, the presence of other foreign companies. Government legislation and local Government intervention to facilitate business locating in an area etc are also factors.

3. Total Costs. The objective is to select a site with the lowest total cost. This includes regional costs, inbound destruction costs, and an outbound distribution costs comprise the regional costs. In addition, there are hidden costs that are difficult to measure such as loss of customer responsiveness arising from locating away from the main customer base.

4. Infrastructure

Adequate road, rail, air and sea transportation is vital. Energy & telecommunications requirements must also be met. In addition, the local government willingness to invest in upgrading infrastructure to the level required may be an incentive to select a specific location.

5. Quality of Labor

The educational and skill levels of the labor pool must match the company's needs. Primary labor considerations relate to the cost and availability of labor, wage relates in an area, labor productivity, attitude, and towards work.

6. Suppliers

A high quality and competitive supplier base makes a given location suitable.

7. Location of raw materials

Firm's location near or at the source of raw materials for three primary reasons; necessity, perishability, and transportation costs for example, mining and frosty firms must locate at the source of necessity. Those firms that produce short shelf –life products take perishability as primary criteria when consider location.

B. Community Considerations

From a company standpoint, a number of factors determine the desirability of a community as a peace for its workers and managers to live. They include:

- Facilities for education, shipping, recreation transportation, religious workshop, entertainment, the quality of policy, fore and medical services
- attitude towards the company
- The size of the community
- Cost and availability of utilities
- Environmental regulations
- Taxes and
- Existence of development support or incentive.

C. Site related factors.

The primary consideration related to site involves land, transpiration, and zoning or other restrictions, utilities etc.

Service location Vs manufacturing facilities

Service facilities are more common than new factories and warehouses because of their low cost of establishing a service facility compared to one for manufacturing e.g. restaurants, hotels entertaining facilities retail shops etc. Typically have multiple sites to maintain close contact with customers. The location decision is closely tied to the market selection decision. Whereas manufacturing location decisions are often make by minimizing costs, but profit maximizing for service location.

3.9.2. Facility Location Methods /Models

Various quantitative models are used to help determine the best location of facilities. Evaluation of alternative regions, sub regions, and community is termed micro analysis. Evaluation of specific sites in the selected community is termed micro analysis.

Techniques used to support macro analysis include:

1. Breakeven analysis (cost – profit - volume analysis)
2. Factor rating method
3. The Center of gravity method and
4. Linear programming (transportation model)

1. Cost Profit Volume Analysis

The economic comparison of location alternatives is facilitated by the use of cost-volume profit analysis. The analysis can be done numerically or graphically.

Graphical assumptions:

1. Fixed costs are constant for the range of probable output.
2. Variable costs are linear for the range of probable output.
3. The required level of output can be closely estimated
4. Only one product is involved.

Graphical procedure

Step 1 Determine the fixed and variable costs associated with each location alternative.

Step 2 Plot the total-cost lines for all location alternatives on the same graph.

Total cost = FC + VC x Q

Where;

FC = fixed cost

VC = variable cost per unit

Q = quantity or volume of output

Step 3 Determine which location will have the lowest total cost for the expected level of output.

Alternatively, determine which location will have the highest profit.

2. **Factor rating method**

Factor ratings are frequently used to evaluate location alternatives because

1. their simplicity facilitates communication about why one site is better than another
2. they enable mangers to bring diverse location consideration into the evaluation process
3. Then faster consistency and judgment about location alternatives.

Procedures:

1. List the most relevant factors in the location decision
2. Assign a weight to each factor that indicates its relative importance compared with all other factors. The weight sum should be 1.00
3. Decide on a common scale for all factors. Each factors should be rated, say form 1 (very low) to 5 (very high) , according to its relative importance
4. Score rate each location alternative (1 -100)or (1-10)
5. Multiply factor weight or rate by the score (location rate for each factor , and sum the results for each location alternatives
6. Choose the location that has the highest composite score. The score indicates alternative locations are most promising.

3. **Center of gravity method:**

For locating single facilities that considers the existing facilities, the distance between them, and the volumes of goods that need to be shipped. It is used to locate intermediate or distribution warehouses.

This method begins by locating the existing locations on a coordinate grid system. The purpose is to establish relative distance between locations.

3.10 Job Design and Work Measurement

First, a company determines its objectives, and then it develops an operations strategy to achieve those objectives. Part of the operations strategy is designing a work system, which provides the structure for the productivity of the company. The work system includes job design, work measurement, and worker compensation. The company determines the purpose of each job, what the job consists of, and the cost of the employees to do the job. A job must add value and enable the company to achieve its objectives.

Job Design

Job design: specifies the work activities of an individual or a group in support of an organization ‘s objectives. You design a job by answering questions such as: What is your description of the job? What is the purpose of the job? Where is the job done? Who does the job? What background, training, or skills does an employee need to do the job? For example, if one of your company’s objectives is to establish itself as a leader in customer service, jobs must be designed to encourage and reward good customer service practices. In addition, performance measurements for each job must validate the behavior that supports the company’s objective. Let ‘s look at three additional factors in job design: technical feasibility, economic feasibility, and behavioral feasibility.

Technical Feasibility: The technical feasibility of a job is the degree to which an individual or group of individuals is physically and mentally able to do the job. The more demanding the job, the smaller is the applicant pool for that job.

Economic Feasibility: The economic feasibility of a job is the degree to which the value a job adds and the cost of having the job done create profit for the company. If the job as it is designed costs more than the value it adds, then it is not economically feasible.

Behavioral Feasibility : The behavioral feasibility of a job is the degree to which an employee derives intrinsic satisfaction from doing the job. The challenge is to design a job so the worker feels good about doing the job and adds value by doing it.

Specialization in Business

Specialization: Work that concentrates on some aspect of a product or service.

Level of Labor Specialization

The higher the level of specialization, the narrower is the employee ‘s scope of expertise. The professions medicine, law, academics are highly specialized; however, some low- level assembly or service jobs are also specialized.

In the professions, worker satisfaction is one reason for specialization in a particular area of expertise. A doctor who specializes in heart disease, a lawyer who specializes in international law or a professor who specializes in operations management may do so because of intrinsic satisfaction in the job. Without question, other factors also influence people to enter into particular professional careers.

On the other hand, an assembly or service worker whose work is highly specialized often has a monotonous job. These individuals may have narrowly focused jobs be- cause their skill levels are limited. Yet specialized assembly and service workers con- tribute to organizational objectives because they yield high productivity and low unit costs. Consider the assembly worker who inserts and tightens four bolts into each product as it passes by on the assembly line. The work is repetitive, but the worker quickly becomes very proficient. A file clerk who spends eight hours each day filing documents and the data-entry person keying in data eight hours each day also have highly specialized, narrowly focused jobs.

Eliminating Employee Boredom

Companies that choose highly specialized job design have several options for reducing worker boredom, including job enlargement, job enrichment, and job rotation.

Job enlargement: is the horizontal expansion of a job. The job designer adds other related tasks to the job so the worker produces a portion of the final product that he or she can recognize. For example, an assembly worker gets to do additional tasks that complete a portion of the final product, which enables the worker to experience pride in the final product. The worker can then point to the final product and take pride in the portion that he or she was responsible for building. By reducing the level of specialization, however, job enlargement may result in some lost productivity compared to what was specified in the original job design.

One example of job enlargement concerns employees proofreading telephone di- rectories. Rather than proofreading randomly assigned pages, a proofreader is responsible for specific letters in the alphabet. The proofreader can identify those portions of the directory that he or she proofread. Job enlargement is used to instill worker pride in the final product and give the employee some task variety.

Job enrichment: is the vertical expansion of a job. The job designer adds worker responsibility for work planning and/or inspection. This allows the worker some control over the workload in terms of scheduling although not in terms of how much work to do—and instills a sense of pride in the worker.

Job rotation: exposes a worker to other jobs in the work system. Rotation allows workers to see how the output from their previous assignment is used later in the production or service process. Workers see more of the big picture and have a better over- all understanding of the work system. In addition, they acquire more skills that may increase their value to the company. Job rotation provides more flexibility for the company, as its workers have upgraded skills.

Team Approaches to Job Design

Another option for job design is using teams rather than individuals for certain assignments. Problem-solving teams, special-purpose teams, and self-directed teams are three different kinds of employee teams.

Problem-solving teams: are small groups of employees who meet to identify, analyze, and solve operational problems. Employees typically volunteer to participate in problem-solving teams, and team members are trained in problem-solving techniques and data collection. A team may meet once a week, during normal working hours, for one to two hours. After the team has completed its initial training, it concentrates on a particular operational problem. The team analyzes the problem, collects data, develops alternative solutions, and then presents a proposed solution to upper management. Management then decides whether or not to use the proposed solution.

The purpose of problem-solving teams is to use the employees ‘knowledge of operational procedures. Management cannot know as much about detailed operations as the employees who

do the work daily. Problem-solving teams are useful for improving operations and as a way to improve communications between employees and management.

Special-purpose teams: address issues of major significance to the company. They are often short-term, special task forces with a focused agenda. Members of special-purpose teams typically represent several functional areas for an overall view of the problem. For example, a university might use a special-purpose team to hire a new, high-level administrator. The team has a specific task and a limited time frame to do that task. Since the new administrator will have many constituencies, the team may consist of representatives from each college, the operating staff, the professional/administrative staff, trustees, alumni, and students. Including each constituency in the selection process ensures that their concerns are made known.

Self-directed or self-managed teams: are designed to achieve a high level of employee involvement and an integrated team approach. A self-directed team is a group of people working together in their own ways toward a common goal that the team has defined. The team decides on compensations and disciplinary actions when team rules are broken and acts as a profit center. A self-managed team is a group of people working together in their own ways toward a common goal that is defined by a source outside of the team. The team does its own work scheduling and training and pro- vides its own rewards and recognition, but does not set its overall objective.

Ergonomics and the Work Environment

Ergonomics (human factors)

- The scientific discipline concerned with the understanding of interactions among human and other elements of a system
- Ergonomics is the study of the interface between man and machine
- Operator input to machines
- Feedback to operators
- The work environment: Illumination, Noise, Temperature, Humidity

Three domains of ergonomics

- Physical (repetitive movements, layout, health, safety)
- Cognitive (mental workload, decision making, and work stress)
- Organizational (communication, teamwork, work design, and telework)

Methods Analysis

Methods analysis: is the study of how a job is done. Whereas job design shows the structure of the job and names the tasks within the structure, methods analysis details the tasks and how to do them.

Methods analysis is used by companies when developing new products or services and for improving the efficiency of methods currently in use. Suppose your restaurant has an accepted procedure for communicating a customer ‘s dinner choices to the kitchen without errors. Methods analysis documents this accepted procedure, including specific notations that identify

customer preferences. The result is a standard operating procedure your restaurant can use for training new employees and for evaluating the performance of existing employees.

Methods analysis consists of the following steps:

1. Identify the operation to be analyzed.
2. Gather all relevant information about the operation, including tools, materials, and procedures.
3. Talk with employees who use the operation or have used similar operations. They may have suggestions for improving it.
4. Chart the operation, whether you are analyzing an existing operation or a new operation.
5. Evaluate each step in the existing operation or proposed new operation. Does the step add value? Does it only add cost?
6. Revise the existing or new operation as needed.
7. Put the revised or new operation into effect, and then follow up on the changes or new operation. Do your changes to the existing operation improve it? Does your new operation add to the company's overall operations?

Motion Study

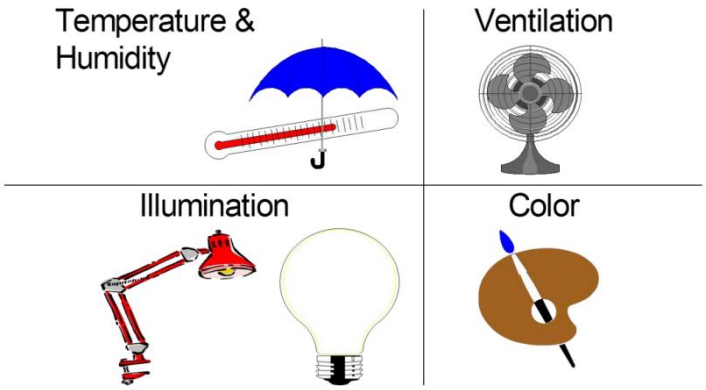
Motion Study is systematic study of the human motions used to perform an operation In developing work methods that are motion efficient, the analyst attempts to

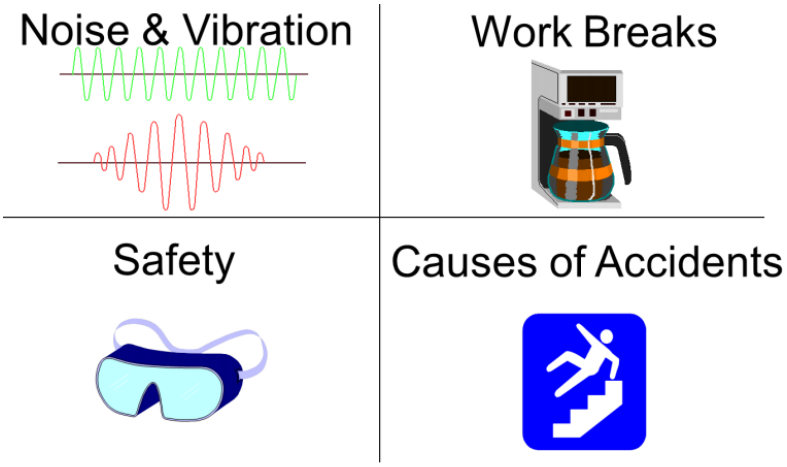
- Eliminate unnecessary motions
- Combine activities
- Reduce fatigue/tiredness
- Improve the arrangement of the workplace
- Improve the design of tools and equipment

Motion Study Techniques

- **Motion study principles -** guidelines for designing motion-efficient work procedures
- **Analysis of therbligs -** basic elemental motions into which a job can be broken down
- **Micromotion study** - use of motion pictures and slow motion to study motions that otherwise would be too rapid to analyze
- **Charts:** such as process charts, activity charts & simo chart
- **Simo Chart:** study simultaneous motions of hands

Quality of Work Life: Working Conditions





Quality of Work Life: Compensation

- It is important for organizations to develop suitable compensation plans for their employees

Compensation approaches

- **Time-based systems**
- **Output-based (Incentive) systems**
  - Individual incentive plans
  - Group incentive plans
  - Management compensation
  - Recent Trends

Knowledge-based systems

Work Measurement

The third component in work system design, work measurement, is a way of determining how long it should take to do a job. Work measurement techniques are used to set a standard time for a specific job. The standard time is the time it should take a qualified operator, working at a

sustainable pace and using the appropriate tools and process, to do the job. The standard time is the sustainable time it takes to do either a whole job or a portion or element of a job. In our restaurant example, the time needed to take the customer‘s order and communicate that information to the kitchen staff can be calculated as the standard time.

Work Measurement Techniques

Commonly used work measurement techniques:

- Stopwatch time study/time studies
- Historical times/historical experience/ standard elemental time
- Predetermined data/predetermined time standards
- Work Sampling

A. Stopwatch Time Study/Time studies

It is used to develop a time standard based on observations of one worker taken over a number of cycles.

- Involves timing a sample of a worker‘s performance and using it to set a standard
- Requires trained and experienced observers
- Cannot be set before the work is performed

Steps

1. Define the task to be studied, and inform the worker who will be studied
2. Divide the task into precise elements
3. Decide how many times to measure the task (number of times or cycles needed)
4. Time and record element times and rating of performance/time the job, and rate the worker ‘s performance
5. Compute average observed time

$$\text{Average observed time} = \frac{\left(\text{Sum of the times recorded to perform each element}\right)}{\text{Number of observations}}$$

6. Determine performance rating and normal time

Normal time = Average Observed Time x Performance Rating Factor

7. Add the normal times for each element to develop the total normal time for the task
8. Compute the standard time

$$\text{Standard Time} = \frac{\text{Total Normal Time}}{\text{1-allowance factor}}$$

Rest Allowances

- Personal time allowance
  4% - 7% of total time for use of restroom, water fountain, etc.
- Delay allowance
  Based upon actual delays that occur
- Fatigue allowance
  - Based on our knowledge of human energy expenditure

B. Standard Elemental Times/historical experience

- are derived from a firm‘s own historical time study data.
- How the task was performed last time
- Easy and inexpensive
- Data available from production records or time cards
- Data is not objective and may be inaccurate
- Not recommended

C. Predetermined time standards

- involve the use of published data on standard elemental times.
- Divide manual work into small basic elements that have established times
- Can be done in a laboratory away from the actual production operation
- Uses Methods Time Measurement (MTM)
- Can be set before the work is actually performed
- No performance ratings are necessary

D. Work sampling

- a technique for estimating the proportion of time that a worker or machine spends on various activities and idle time.
- Estimates percent of time a worker spends on various tasks
- Requires random observations to record worker activity
- Determines how employees allocate their time
- Can be used to set staffing levels, re-assign duties, estimate costs, and set delay allowances

Advantages of work sampling

- Less expensive than time study
- Observers need little training
- Studies can be delayed or interrupted with little impact on results
- Worker has little chance to affect results
- Less intrusive / disturbance

Disadvantages of work sampling

- Does not divide work elements as completely as time study

 Can yield biased results if observer does not follow random pattern

 Less accurate, especially when job element times are short

Work Sampling Steps

1. Take a preliminary sample to obtain estimates of parameter values
2. Compute the sample size required
3. Prepare a schedule for random observations at appropriate times
4. Observe and record worker activities
5. Determine how workers spend their time

Determining the sample size $$n = \frac{z^2 p(1 - p)}{h^2}$$

where n = required sample size

z = standard normal deviation for desired confidence level

p = estimated value of sample proportion

h = acceptable error level in percent