PLANT LAYOUT DESIGN
1 Introduction

References

2. Richard L. Francis, Facility Layout and Location.
OUTLINE

◆ Company profile

◆ Definitions

◆ Plant Location

  o Site Selection

  o Theories of Industrial Location

  o Location Economics

  o Selecting Plant in Urban/Rural Areas

  o Site Selection Process
OUTLINE-cont’d

- Objective of a good plant
- Principles of plant layout
- Basic types of plant layout
The head quarter and showroom is located at Nefas Silk Lafto Sub City, Addis Ababa.

The Enterprise has well established maintenance workshop.

The car assembly launches production of different types of vehicles.

- ZHENGZHOU NISSAN, PICK UP DOUBLE CAB, 4WD
- FOTON - Mini Dump Truck
- FOTON - Heavy Duty Tractor Unit
- FOTON - Heavy Duty Dump Truck
- FOTON - Light Duty Truck
- Forlan Van
- FOTON Water Sprinkler, etc.
Plant Layout at Belayab Enterprise

Spare part store

- Products are not arranged properly
- No detailed inventory of stored items and locations.
Plant Layout at Belayab Enterprise

Show Room
  • Not shown from the outside.

Parking Area
  • Not enough to serve customers
Plant Layout at Belayab Enterprise

Assembly Area
- Tools and equipment are not available in the area.
- Parts can be damaged due to environmental causes.

Painting Area
- Don’t have proper area and equipment.
Plant Layout at Belayab Enterprise

Tool Room and Engine house
Plant Layout at Belayab Enterprise

Waste and Scraps are not properly managed
Definitions

◆ A *plant* is a place

◆ Where *men, materials, money, equipment, machinery, etc.* are brought together for manufacturing products.
Plant location means deciding a suitable location, area, place, etc. where the plant or factory will start functioning.
Plant layout means the disposition of the various facilities (equipments, materials, manpower, etc.) and services of the plant within the area of the site selected.
Problems of layout develop when needed:

- To start a new product,
- To change the product design,
- To reduce the cost;

And when

- The market demand changes,
- The plant, the product, the building become obsolete,
- Accidents occur frequently,
- The working environment is poor.
Plant Location

- Choice of *general* area or region.
- Choice of *site* within the area selected.
Location decision is based on the organizations long-term strategies such as technological, marketing, resource availability and financial strategies.

Plant location is important because:

- Location influences plant layout facilities needed.
- Location influences capital investment and operating costs.
Need for location decision:

- When a *new facility* to be established.
- *Expansion of existing* facility.
- To establish *additional facilities* in *new territories* due to growing volume of business.
- When *original advantage* of the plant have been *outweighed* due to new development.
- When *new economics, social, legal* or *political factors* suggest a *change of location* of the existing facility.
Plant location plays a major role in the design of a production system as it determine the cost of:

- Getting suitable raw materials;
- Processing raw material to finished goods; and
- Finished products distribution to customers.
The problem of the selection of a factory or a plant can be solved in the following two stages:

a) The General Location of the Plant

b) The Selection of a Particular site.
a) General Location of the plant

- Availability of Raw Materials
- Proximity to Markets
- Transport Facility
- Availability of Efficient and Cheap Labour
- Availability of Power and Fuel
- Climatic and Atmospheric Conditions

- Availability of Water
- Availability of Capital
- Social and Recreational Facilities
- Business and Commercial Facilities
- Existence of related Industries
- Other factors ...
b) **Specific Site Selection**

- Community Attitude
- Community Facilities
- Topography
- Transportation Facilities
- Waste Disposal
- Ecology and Pollution
- Size of Land
- Supporting Industries
Theories of Industrial Location

All are emphasize on the search for suitable location which offers the greatest difference between total costs and total revenue.

Some important theories on industrial location are:

- *Theory of Maximum Profit Location*
- Location Analogue Model
- *The Interdependence Theory of Location*
- Theory of Least-Cost Location
- *Linear Programming Techniques*
- Weber’s Theory of Location
- *Theory of Location by Sargent*
- Theory of Location by Predohl and others
- Theory of Location by Losch and Walter Israd
Theory of Maximum Profit Location

- Location of manufacturing establishment depends up on the firms cost of production at alternative locations in the market area. - Argus Losch

- Suggested a mathematical model which considers total cost, total revenues, the sales radius and the maximizing net mill price. Considers variations in income between alternative locations. - Green hut
The Interdependence Theory of Location

- Plant location should be based on the ability of a site to control the largest market area. - *Fettler and Hotelling*

- Assumed that the cost of procuring raw materials and processing are equal at all locations.
Linear Programming Techniques

- Provides a means of finding optimum solution to practical problems.
- It can be used in a situation where it is required to maximize or minimize some quantity which is a function of a set of variables, subjected to certain rules or constraints.
- Used for solving plant location problem such as:
  a) The location of single firm.
  b) Inter regional commodity flows and the allocation of production.
  c) The dual and location rent.
  d) Transportation of incoming and distribution of final products.
For evaluation of economical location following factors should be considered:

a) Raw material procurement
b) Proximity to market
c) Availability of labour
d) Availability of power
e) Availability of finance
f) Miscellaneous considerations (donations, subsidies, taxes and non-interference by government or local bodies, war and political effects and other facilities or bottlenecks)
The principle of industrial plant location is that the sum of manufacturing and distributing cost should be at minimum for the best location.
a) Factors for locating an undertaking near the raw material size:

- When source of raw materials is the controlling factor,
- When materials are bulky and of relatively low price,
- When materials are small and of high unit price,
- When raw materials are greatly reduced in bulk during the process of manufacturing,
- When raw materials are perishable and process makes them less perishable.
b) Factors for locating an industry near to market:

- When the size or bulk of the product is more,
- Render it more fragile,
- More susceptibility about the spoilage.
c) Factors related to the economy of labour:
  • The ratio of labour cost to the total manufacturing cost,
  • Possibility of reduction in labour cost by using better method or better quality of labour,
  • The type of labour required.
d) Economy and availability of power

e) Other major factor that influences is availability of finance

f) Miscellaneous considerations
Various costs and other considerations have been listed below as regards to locations 1 and 2. It's required to determine the overall best location.

<table>
<thead>
<tr>
<th>Costs of</th>
<th>Location-1 (Birr)</th>
<th>Location-2 (Birr)</th>
<th>Costs of</th>
<th>Location-1 (Birr)</th>
<th>Location-2 (Birr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Land</td>
<td>1,100,000</td>
<td>1,000,000</td>
<td>h) Raw Material</td>
<td>1,500,000</td>
<td>1,400,000</td>
</tr>
<tr>
<td>b) Building</td>
<td>3,500,000</td>
<td>3,800,000</td>
<td>i) Taxes</td>
<td>300,000</td>
<td>300,000</td>
</tr>
<tr>
<td>c) Water</td>
<td>9,500</td>
<td>12,000</td>
<td>j) Community Facilities</td>
<td>Good</td>
<td>Excellent</td>
</tr>
<tr>
<td>d) Power</td>
<td>500,000</td>
<td>800,000</td>
<td>k) Community attitude</td>
<td>Alright</td>
<td>Encouraging</td>
</tr>
<tr>
<td>e) Labour</td>
<td>600,000</td>
<td>700,000</td>
<td>l) Housing facilities</td>
<td>Very good</td>
<td>Good</td>
</tr>
<tr>
<td>f) Freight</td>
<td></td>
<td></td>
<td>m) Cost of Living</td>
<td>High</td>
<td>Normal</td>
</tr>
<tr>
<td>• In-coming</td>
<td>230,000</td>
<td>220,000</td>
<td>n) Community Size</td>
<td>Small</td>
<td>Medium</td>
</tr>
<tr>
<td>• Out-going</td>
<td>310,000</td>
<td>300,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g) Fuel</td>
<td>120,000</td>
<td>100,000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Cost-1 = 8,219,500 Birr**
**Total Cost-2 = 8,432,000 Birr**

Location 2 is Best.
Location Alternatives

- From the Following Data, the most advantageous location for setting a plant for making Aluminum Extrusion Plant is...

<table>
<thead>
<tr>
<th>Costs of Initial Investment (Birr in mln)</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Akaki</td>
<td>Birr 5</td>
</tr>
<tr>
<td>Sululta</td>
<td>Birr 4.5</td>
</tr>
</tbody>
</table>

- Akaki Site is the most advantageous because:
  - It associates the highest R.O.R.
  - Community attitude is Excellent.

- R.O.R for Lebu = 17.2%
- R.O.R for Akaki = 30%
- R.O.R for Sululta = 5.6%
Economic Factors

a) **Product** - Nature, Volume, value.
b) **Production process** - continuous, intermittent.
c) **Manufacturing machinery**
d) **Services** - Electricity, Water, Sewerage, steam, air.
Selecting the plant site in city (Urban site)

**Advantages**

- A city is very well connected by rails, roads and air.
- It provides a good market also.
- Right labour force is available.
- Power and Water is easily available.
- It has good hospitals, marketing centers, Schools, Banks, etc.
- The factory can be setup in an existing available buildings.
- Workers training classes and many other educational facilities can be cites.
- Services of experts and specialist are easily available.
- Many other small industries are existing
- Security
Disadvantages

• Land available for the building is limited in area
• Cost of land and building construction is high
• Expansion of the industry is seldom possible
• Local taxes, etc ... are high
• Labour salaries are high
Selecting the plant site in a small town (Rural area)

Advantages

- Plenty of land is available for building construction and expansion purposes
- Land is cheap
- Cheap labour force
- Government gives incentives
- Less tax and restriction
Disadvantages

- Skilled labour is not available
- Rail, road and air links may not be there at all or may not be adequate
- Power is not available
Site Selection Process

The following procedures are recommended:

1. Formulate the problem
2. Analyze the problem
3. Search for alternative solutions
4. Evaluate the design alternatives
5. Select the preferred design
6. Specify the solution
OBJECTIVES OF A GOOD PLANT

- Ensure effective space utilization,
- Minimize the cost of material handling (internal transports),
- Foresee future developments of the plant according to a rational master plan,
- Improve workers convenience as well as safety and create job satisfaction, and
- Avoid unnecessary capital investment.
Development stimulating layout problem

Classes of layout problem

- **Product Design Change**
- **New Product**
- **Market Demand Change**
- **Obsolete Facilities**
- **Poor Worker Envir.**
- **Market Relocation**
- **Cost Reduction**

- **Build New Plant**
- **Move to Existing Plant**
- **Rearrange Existing Layout**
- **Minor Changes**

*Colors and Lines Indicate Frequency of Occurrence:*
- **Red**: Cause and result occur frequently
- **Black**: Cause and result occur less frequently
- **Green**: Cause and result occur occasionally
- **Purple**: Cause and result occur very seldom
PRINCIPLES OF A GOOD PLANT LAYOUT

- Overall integration of factors
- Minimum movement
- Uni-directional
- Effective use of available space
- Maximum visibility
- Maximum accessibility
• From the point of view of plant layout, we can classify business or units into three categories:

1. Manufacturing units
2. Traders
3. Service Establishments
Manufacturing units

In case of manufacturing unit, plant layout may be of four types:

a) Product or line layout
b) Process or functional layout
c) Fixed position or location layout
d) Combined or group layout
Product or line layout

• In this type of layout, only one product or one type of product is produced in a given area.

• The product must be standardized and manufactured in large quantities in order to justify the product layout.
• The raw material moves very fast from one workstation to other stations with a minimum work in progress storage and material handling.

   Paper mill bamboos are fed into the machine at one end and paper comes out at the other end.
The grouping of machines should be done keeping in mind the following general principles:

a) All the machine tools or other items of equipments must be placed at the point demanded by the sequence of operations.

b) There should no points where one line crossed another line.

c) Materials may be fed where they are required for assembly but not necessarily at one point.

d) All the operations including assembly, testing, packing must be included in the line.
CONT’D
• Specialized equipment
• High capital intensity & wide use of automation
• Processing rates are faster
• Material handling costs are lower
• Less space required for inventories
• Less volume or design flexibility
Some of the **advantages** of product layout are:

- lower total material handling cost,
- lower total production time,
- less work in process,
- greater incentive for groups of workers to raise level of performance,
- less floor area required per unit of production and
- greater simplicity of production control, fewer control records needed and lower accounting cost.
Some of the **disadvantages** of product layout are:

- High initial capital investment in special purpose machine
- Heavy overhead charges
- Breakdown of one machine will hamper the whole production process
- Lesser flexibility as specially laid out for particular product.
Product Layout is useful under the following conditions

- Mass production of standardized products
- Simple and repetitive manufacturing process
- Operation time for different process is more or less equal
- Reasonably stable demand for the product
- Continuous supply of materials
- Minimum of inspection is required during sequence of operations,
Process or Functional Layout

- *Similar equipment* and *similar operations* are *grouped* together in the process or functional layout.

- It is particularly useful where *low volume* is required.
The grouping of machines according to the process has to be done keeping in mind the following principles

- The distance between departments should be as short as possible for avoiding long distance movement of materials
- The departments should be in sequence of operations
- The arrangement should be convenient for inspection and supervision
Tailoring, light and heavy engineering products, made to order furniture industries.
<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Press Dept.</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Heat treat Dept.</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Painting Dept.</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Milling Dept.</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Packing Dept.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8</td>
</tr>
</tbody>
</table>

Finished Good store

Product A

Product B
Some of the **Advantages** of Process Layout are:

- less duplication of equipment, hence lower investment cost,
- greater flexibility of production,
- better and more efficient supervision,
- greater incentive for individual workers to raise level of performance,
- better control of complicated or precision processes,
- Breakdown of one machine does not result in complete work stoppage
- Change in output design and volume can be more easily adapted to the output of variety of products
Some of the **Disadvantages** of Process Layout are:

- Material handling costs are high due to backtracking
- More skilled labour is required resulting in higher cost.
- Time gap or lag in production is higher
- Work in progress inventory is high needing greater storage space
- More frequent inspection is needed which results in costly supervision
Process Layout is useful under the following conditions:

- Products are not standardized
- Quantity produced is small
- There are frequent changes in design and style of product
- Job shop type of work is done
- Machines are very expensive
Fixed-Position Layout

• In this type of layout, the material or major component remains in a *fixed location*, and tools, machinery, men as well as other pieces of material are brought to this location.

• Typical examples are ship building, construction industries, aircraft building and bench work exercises.

• This type of layout is not frequently used in industrial enterprises.
Some of the **Advantages** of Fixed Position Layout are:

- It saves time and cost involved on the movement of work from one work station to another.
- The layout is flexible as change in job design and operation sequence can be easily incorporated.
- It is more economical when several orders in different stages of progress are being executed simultaneously.
- Adjustments can be made to meet shortage of materials or absence of workers by changing the sequence of operations.
Some of the **Disadvantages** of Fixed Position Layout are:

- Production period being very long, capital investment is very heavy.
- Very large space is required for storage of material and equipment near the product.
- As several operations are often carried out simultaneously, there is possibility of confusion and conflicts among different workgroups.
Fixed Position Layout is useful under the following conditions

- Manufacture of bulky and heavy products such as locomotives, ships, boilers, generators, aircraft manufacturing, etc.
- Construction of building, dams, etc.
- Hospital, the medicines, doctors and nurses are taken to the patient (product).
Combination Layout

• Certain manufacturing units may require all three processes namely intermittent process (job shops), the continuous process (mass production shops) and the representative process combined process [i.e. miscellaneous shops].

• Combination of the product and process layout or other combination are found, in practice, e.g. for industries involving the fabrication of parts and assembly, fabrication tends to employ the process layout, while the assembly areas often employ the product layout.
• When two outlets carry almost same merchandise, customers usually buy in the one that is more appealing to them.

• Thus, customers are attracted and kept by good layout i.e. good lighting, attractive colors, good ventilation, air conditioning, modern design and arrangement and even music.

• All of these things mean customer convenience, customer appeal and greater business volume.
• The customer is always impressed by service, efficiency and quality.

• There are three kinds of layouts in retail operations today.

  1. Self service or modified self service layout
  2. Full service layout
  3. Special layouts
SERVICES CENTERS AND ESTABLISHMENT

- Services establishments such as Banks, Insurance, Motels, Hotels, Restaurants, must give due attention to client convenience, quality of service, efficiency in delivering services and pleasing office ambience.
- In today’s environment, the clients look for ease in approaching different departments of a service organization and hence the layout should be designed in a fashion, which allows clients quick and convenient access to the facilities offered by a service establishment.
• The solution of any size and type of plant layout problems could be facilitated by using a systematic and logical approach.

• An early pioneer in this area was Richard Muther, developer of the *Systematic Layout Planning (SLP)* methodology.
The SLP procedure leads the planner through

- **Abstraction (Analysis):** Gathering appropriate information and analyzing the *flow of materials* and the *activity relationships* to form a *relationship diagram*.

- **Space considerations** when combined with the *relationship diagram* develop the *space relationship diagram*.
• **Search (for possible solution):** The overall layout is designed by combining space consideration with the relationship diagram.

• The search phase is the phase in which alternative layouts are developed by examining the *space relationship diagram* under *modifying consideration* such as materials handling, storage facilities, site conditions and surroundings, building types, personnel convenience, etc., and *practical limitations.*
• **Selection**: The most efficient general method of evaluating layout alternatives is termed factor analysis. It follows the engineering concept of breaking down the problem into its elements and analyzing each one.