

INNOVATIVE PRACTICES IN FACILITY LAYOUT PLANNING

MAHENDRA SINGH

Asst. Professor, Centre for Business Administration,
Central University of Jharkhand, Ranchi.

ABSTRACT

Facility layout is where the pen meets the paper in the design and operation of a production system. A good factory layout can provide real competitive advantage by facilitating material and information flow processes. It can also enhance employees' work life and improved productivity can be achieved. Plant layout is one way to reduce the cost of manufacturing. A systematic service layout can be an effective "stage" for playing out the services to customers. The layout problem has relevance in many areas of facility and equipment design. The paper aims on studying various types of basic facility layout and advanced facility layouts in practice as well. Study is also aimed on application of Innovative practices in Facility layout planning. The key innovative practices in facility layout planning includes few of the modern Facility Layout Planning designs viz. CRAFT(Computerized Relative Allocation of Facilities Technique),SLP(systematic layout planning),QAP(Quadratic Assignment Problem), and Basic models like Assembly line balancing, Mixed model line balancing, Group technology layouts, Material handling cost method, Flexible manufacturing system(FMS) too. The desired results from present paper is towards the finding out way of facility locations designs offering better productivity and enhanced overall organizational efficiency in all-around.

Keywords: Facility layout, SLP, CRAFT, QAP, FMS, GT, Assembly line balancing
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INTRODUCTION:

In Era of increasing demand in production, industrial factories need to increase their potentials in production and effectiveness to compete against their market rivals. At the same time, the production process needs to be equipped with the ability to have lower cost with higher effectiveness. Therefore, the way to solve the problem about the production is very important. There are many ways i.e. quality control (QC), total quality management (TQM), standard time, plant layout to solve the problems concerning productivity. Plant layout decisions entail determining the placement of departments, work groups within the departments, workstations, machines, and stock-holding points within a production facility. The objective is to arrange these

elements in a way that ensures a smooth work flow in a manufacturing unit or a particular traffic pattern in a service organization. Plant layout is one way to reduce the cost of manufacturing and increase the productivity. Also increases good workflow in production route. The efficiency of production depends on how well the various machines; production facilities and employee's amenities are located in a plant. Only the properly laid out plant can ensure the smooth and rapid movement of material, from the raw material stage to the end product stage. Plant layout encompasses new layout as well as improvement in the existing layout. Plant layout refers to the arrangement of physical facilities such as machinery, equipment, furniture etc. within the factory building in such a manner so as to have quickest flow of material at the lowest cost and with the least amount of handling in processing the product from the receipt of material to the shipment of the finished product. It may be defined as a technique of locating machines, processes and plant services within the factory so as to achieve the right quantity and quality of output at the lowest possible cost of manufacturing. It involves a judicious arrangement of production facilities so that workflow is direct. J. L. Zundi, defines "Plant layout ideally involves allocation of space and arrangement of equipment in such a manner that overall operating costs are minimized. Riggs defines, "the overall objective of plant layout is to design a physical arrangement that most economically meets the required output – quantity and quality."

Importance of Systematic facility layout planning:

An ideal plant layout provides the optimum relationship among output, floor area and manufacturing process. It facilitates the production process, minimizes material handling, time and cost, and allows flexibility of operations, easy production flow, makes economic use of the building, promotes effective utilization of manpower, and provides for employee's convenience, safety, comfort at work, maximum exposure to natural light and ventilation. It is also important because it affects the flow of material and processes, labour efficiency, supervision and control, use of space and expansion possibilities



Figure: *Systematic facility layout facilitates at our manufacturing units.*

Innovative Practices in Plant Layout Designing:

The modern manufacturing units are having most sophisticated and advanced plant layout. The layouts by which departments are arranged in a facility are defined by the general pattern of work flow; there are three basic types (process layout, product layout, and fixed-position layout) and one hybrid type (group technology or cellular layout), group technology (cellular) layout are also used widely now days. Many manufacturing facilities present a combination of two layout

types. For example, a given production area may be laid out by process, while another area may be laid out by product. It is also common to find an entire plant arranged according to product layout like, a parts painting area followed by a subassembly area, with a final assembly area at the end of the process. Different types of layouts may be used in each area, with a process layout used in fabrication, group technology in subassembly, and a product layout used in final assembly.

1. Process Layout:

Process Layout involves arranging departments consisting of like processes in a way that optimizes their relative placement. In many installations, optimal placement often means placing departments with large amounts of interdepartmental traffic adjacent to one another. The work has to be allocated to each department in such a way that no machines are chosen to do as many different job as possible i.e. the emphasis is on general purpose machine. The work, which has to be done, is allocated to the machines according to loading schedules with the object of ensuring that each machine is fully loaded. The grouping of machines according to the process may be done keeping in mind the following principles of process layout designing.

- The distance between departments should be as less as possible for avoiding long distance movement and handling of materials.
- The Layout should be in sequence of manufacturing operations.
- The arrangement should be convenient for inspection and supervision

| Advantages | Disadvantages | Suitability |
|--|---|--|
| <ul style="list-style-type: none"> • Lower initial capital investment • high degree of machine utilization, • Low overhead costs • variety of products • Effective and speciliaerd supervision • Greater Flexibility and expansion scope | <ul style="list-style-type: none"> • Material handling Cost is high • More Skilled labour requirement • Gap in Production is Higher • WIP inventory is High • Moer frequent inspection is needed resulting in high cost • Mostaly non standerdized product are produced | <ul style="list-style-type: none"> • Where Prodction volume required is lower • Products are not standardized • There are frequent changes in design and style of product • Job shop type of work is done • Machines are very expensive |

Thus, process layout or functional layout is suitable for job order production involving non-repetitive processes and customer specifications and non-standardized products.

2. Product layout:

Product layout is arrangement where machines and equipment are arranged in one line depending upon the sequence of operations required for the product. The materials move from one workstation to another sequentially without any backtracking or deviation. Under this, machines are grouped in one sequence. Therefore materials are fed into the first machine and finished goods travel automatically from machine to machine, the output of one machine becoming input of the next. The raw material moves very fast from one workstation to other stations with a minimum work in progress storage and material handling. The grouping of machines should be done by following principles.

- All the operations including assembly, testing packing must be included in the Product line
- All the machine tools or other items equipment's must be placed at the point demanded by the sequence of operations
- There should no points where one line inters another line. Materials may be supplied where they are required for assembly.

| Advantages | Disadvantages | Suitability |
|--|---|---|
| <ul style="list-style-type: none"> • Low cost of material handling • Smooth,uninterrupted operations • Continuous flow of work • Lesser investment in inventory and WIP • Optimum use of floor space • Shorter processing time • Less congestion of work in the process • Simple and effective inspection of work and simplified production control • Lower cost of manufacturing | <ul style="list-style-type: none"> • 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. | <ul style="list-style-type: none"> • 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 |

Therefore, the manufacturing units involving continuous manufacturing process, producing few standardized products continuously on the firm's own specifications and in anticipation of sales would prefer product layout.

3. Fixed Position Layout:

This is the type of layout in which the major product being produced is fixed at one location. Equipment labour and components are moved to that location. All facilities are brought and arranged around one work center. This type of layout is not relevant for small scale entrepreneur.

| Advantages | Disadvantages | Suitability |
|--|--|---|
| <ul style="list-style-type: none"> • It saves time and cost involved on the movement of work from one workstation 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. | <ul style="list-style-type: none"> • 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. | <ul style="list-style-type: none"> • Manufacture of bulky and heavy products such as locomotives, ships, boilers, generators, wagon building, aircraft etc. • Construction of building, flyovers, dams. • Hospital medical services. |

4. Combined layout or Group Technology:

Many of Production units require all three processes namely intermittent process (job shops), the continuous process (mass production shops) and the representative process combined process or miscellaneous shop production. In most of industries, only a product layout or process layout or fixed location layout does not exist. Thus, in manufacturing concerns where several products are produced in repeated numbers with no likelihood of continuous production, combined layout is followed. Generally, a combination of the product and process layout or other combination are found, in practice, e.g. for industries involving the fabrication and manufacturing of parts and assembly, fabrication tends to employ the process layout, while the assembly areas often employ the product layout. In Corn, manufacturing plant, the machinery manufacturing corns is arranged on the product line principle, but ancillary services such as heating, the mixing of spices, the power house, the water treatment plant etc. are arranged on a functional basis.

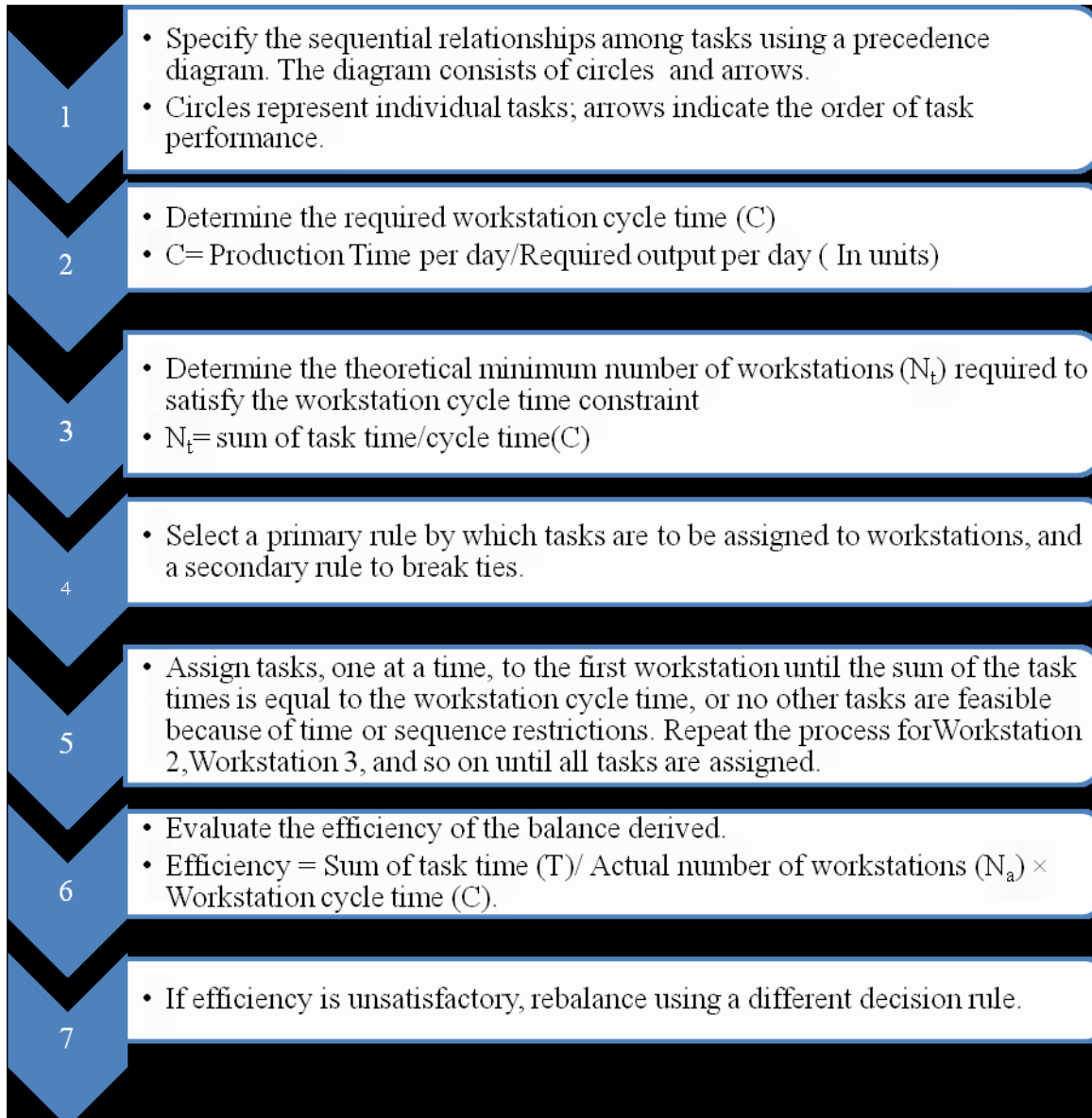
5. Systematic Layout Planning:

Few of the plant layout problems, numerical flow of items between departments either is impractical to obtain or does not reveal the qualitative factors that may be crucial to the placement decision. In these situations, the venerable technique known as systematic layout planning (SLP) can be used, which is carried on developing a relationship chart showing the degree of importance of having each department located adjacent to every other department. From this informational chart, an activity relationship diagram, flow graph is developed. The activity relationship diagram is then adjusted by **trial and error** until a satisfactory adjacency pattern is obtained. This pattern, in turn, is modified department by department to meet building space limitations. The SLP approach has been quantified for ease of evaluating alternative layouts. This entails assigning numerical weights to the closeness preferences and then trying different layout arrangements. The layout with the highest total closeness score is chosen.

6. Assembly Line Balancing:

In most of the cases where number of workstation and jobs to be done is numerous we had to do assembly line balancing. Purpose of assembly line balancing is to minimize number of workstations and reduce delay time in the cycle resulting in higher total productivity. Though primarily a scheduling issue, assembly-line balancing often has implications for layout. This would occur when, for balance purposes, workstation size or the number used would have to be physically modified. The most common assembly line is a moving conveyor that passes a series of workstations in a uniform time interval called the workstation cycle time (which is also the time between successive units coming off the end of the line). At each workstation, work is performed on a product (or assemblies) either by adding parts or by completing assembly operations. The work performed at each station is made up of many bits of work, termed tasks, elements, and work units. Such tasks are described by motion-time analysis. Generally, they are groupings that cannot be subdivided on the assembly line without paying a penalty in extra motions. The total work to be performed at a workstation is equal to the sum of the tasks assigned to that workstation. The assembly-line balancing problem is one of assigning all tasks to a series of workstations so that each workstation has no more than can be done in the workstation cycle time, and so that the unassigned (that is, idle) time across all workstations is minimized. The problem is complicated by the relationships among tasks imposed by product design and process technologies. This is called the precedence relationship, which specifies the order in which tasks must be performed in the assembly process.

Steps in an assembly line balancing:



7. Computerized facility layout Techniques:

Now days use computer is well established in every type of designing so is the facility layout also. A number of computerized layout programs have been developed since the 1970s to help devise good manufacturing layouts. Out of these, the most widely applied is the Computerized Relative Allocation of Facilities Technique (CRAFT). The CRAFT method follows the same basic idea, but with some significant operational differences, it requires a load matrix and a distance matrix as initial inputs, but in addition, it requires a cost per unit distance traveled. With basic inputs and an initial layout in the program, CRAFT tries to improve the relative placement of the departments as measured by total material handling cost for the layout. (Material handling cost between departments (Flow points) = Number of loads \times Rectilinear distance between department centroids \times Cost per unit distance.) It makes improvements by exchanging pairs

of departments iteratively until no further cost reductions are possible. That is, the program calculates the effect on total cost of exchanging departments; if this yields a reduction, the exchange is made, which constitutes iteration. departments are part of a material flow network, so even a simple pairwise exchange generally will affect flow patterns among many other departments. It is a heuristic program.

1. CRAFT uses a simple rule of thumb in making evaluations that is Compare two departments at a time and exchange them if it reduces the total cost of the layout. This type of rule is obviously necessary to analyze even a modest size layout.
2. CRAFT does not guarantee an optimal or model solution.
3. CRAFT is biased by its starting conditions: where you start (that is, the initial layout) will determine the final layout.
4. Starting with a reasonably good solution is more likely to yield a lower-cost final solution, but it does not always. This means that a good strategy for using CRAFT is to generate a variety of different starting layouts to expose the program to different pairwise exchanges.
5. It can handle up to 40 departments and rarely exceeds 10 iterations in arriving at a solution.
6. CRAFT departments consist of combinations of square modules. This permits multiple departmental configurations, but often results in strange departmental shapes that have to be modified manually to obtain a realistic layout.
7. A modified version called SPACECRAFT has been developed to handle multistory layout problems.
8. CRAFT assumes the existence of variable-path material handling equipment such as forklift trucks. Therefore, when computerized fixed-path equipment is employed, CRAFT's applicability is greatly reduced.

The result of design shows minimum total transfer cost between departments. The calculation is

Based on the following equations:

$$\text{Minimize } C = \sum_{i=1}^n \sum_{j=i+1}^n f_{ij} c_{ij} d_{ij} \quad (1)$$

C : Total Transfer Cost

f_{ij} : Transfer Rate From i To j

c_{ij} : Cost of Transfer From i To j

d_{ij} : Distance From i To j (From Centroid)

If the distance between departments are rectilinear, d_{ij} is calculated based on Equation (2).

$$d_{ij} = |\Delta x| + |\Delta y| \quad (2)$$

If the distance between departments are euclidean, d_{ij} is calculated based on Equation (3).

$$d_{ij} = \sqrt{(\Delta x)^2 + (\Delta y)^2} \quad (3)$$

To calculate the distance between departments, centroid of each department is calculated using equation(4) and (5).

$$X = \frac{1}{A} \int_{y_1}^{y_2} \int_{x_1}^{x_2} x dx dy = \frac{1}{2A} (x_2^2 - x_1^2) \times (y_2 - y_1) \quad (4)$$

$$Y = \frac{1}{A} \int_{x_1}^{x_2} \int_{y_1}^{y_2} y dy dx = \frac{1}{2A} (y_2^2 - y_1^2) \times (x_2 - x_1) \quad (5)$$

Based on these calculations, the result design will show only a transfer cost between departments. The good result design means less transfer cost between departments. However, there are other parameters missing such as total time in system, waiting time, or utilization.

Plant Layout using Simulation:

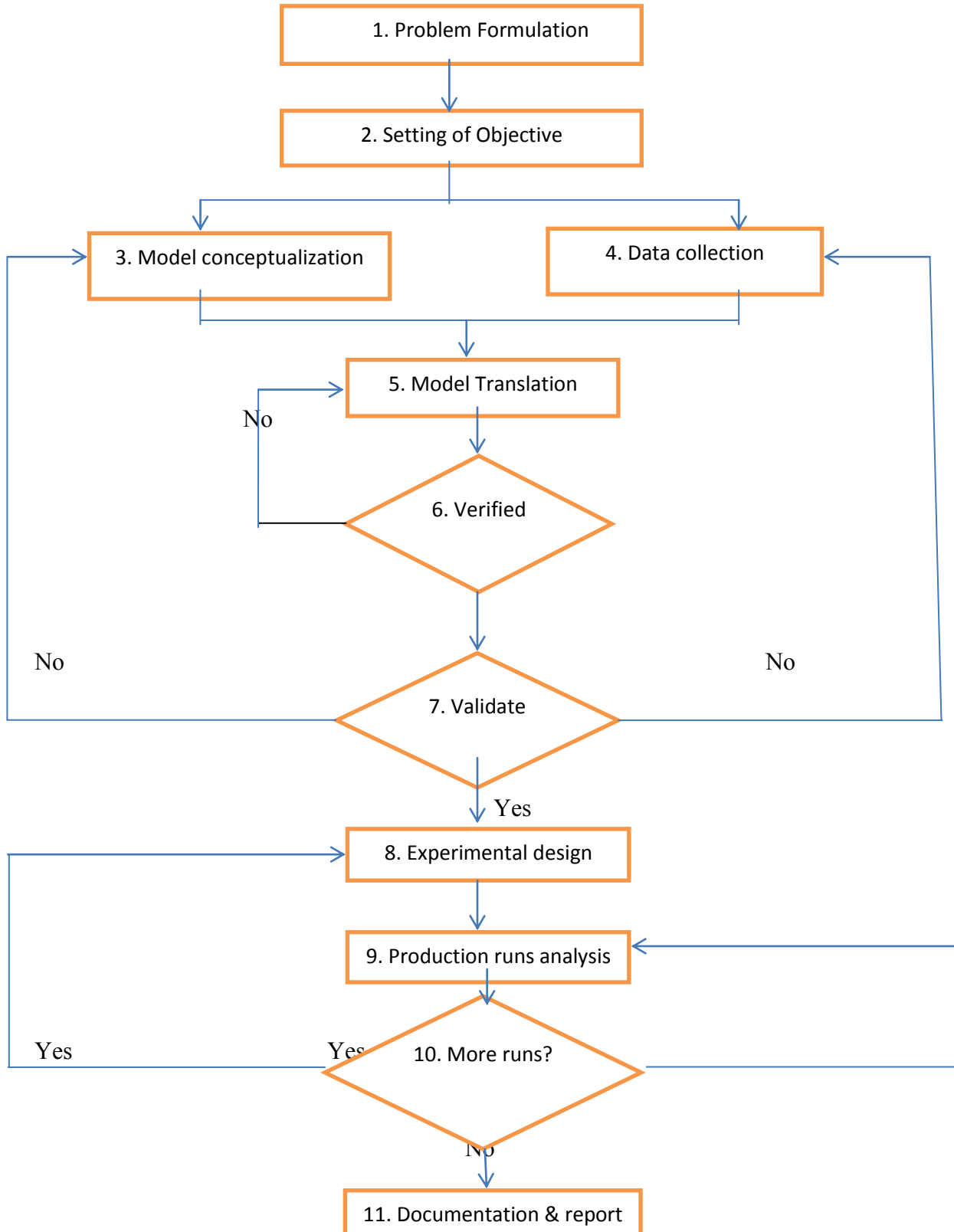
Simulation refers to a broad collection of methods and applications to mimic the behavior of real systems, usually on a computer with appropriate software. Today, simulation is more popular and powerful than ever since computers and software are better than ever. Simulation has many aspects that do tend to come up with a layout design. Based on the missing of some information from the traditional plant layout design, the simulation technique is added to the traditional plant layout design to show more information such as total time in system, waiting time, and utilization. As a new concept, there must be a system that can search for a good layout and then can show more important information about production. Both concepts are implemented as computer software with the plant layout design module and the plant layout simulation module. These modules are developed based on Microsoft Visual Basic program. First, there is a Microsoft Visual Basic Graphic User Interface (GUI) to receive input such as product type, product quantity, department list, department dimension, From-To Chart. This module is also developed based on Microsoft Visual Basic program to swap all departments to get minimum total transfer cost between departments.

The number of swap can be calculated using equation:

$$M = N(N-1)/2$$

Where N = Number of departments

The activities to be done can be put in to a flow diagram which will enable us to find out better solution to problem.



Conclusion:

Facility design is crucial issue for production related decisions. The efficiency and productivity depends on the type of manufacturing layout is being used for production of goods and services. Not only efficiency is increased directly but indirectly good facility layout also contributes to efficiency by reducing accidents, hazards, by increasing easiness and convenience. Most importantly a better facility design allows smooth function off manufacturing. Material handling and transportation are well facilitated in good facility layout. Now days besides using basic designs like product layout, process layout, group layout and combination layout various advanced type of layouts are being designed as per the custom requirement of manufacturing. The innovative methods of facility design include methods like assembly Line balancing, Systematic layout planning, Computerized Relatively allocating of facility technology and simulation methods. Hence it is surer that innovations at facility designing practices show our efficient operations management practices.

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