CHAPTER - 1

INTRODUCTION AND OVERVIEW

1.1. INTRODUCTION

Production management is concerned with the design, construction, operation and control of production systems. Optimal management of production systems requires optimum decision making at planning and control phases. Planning encompasses preproduction activities such as forecasting of demand, designing products, selecting equipments and processes, designing jobs, location and layout of the facilities and so on. Control, on the other hand, refers to operations which occur during production or operation stage and include inventory and production control, quality control, maintenance and replacement etc.

Tonge[7] states, "the over-all company production decision is influenced by demand estimates, estimates of the amount of product in the distribution system, and estimates of the cost of unfilled orders and the 'scrap' value of overproduction. From these factors a firm demand for product over time is synthesized. Production management strives to meet that demand at minimum cost. Indeed, in general there is a set of demands for different products over time, each competing for a share of scarce company resources".

The nature of such problems depends to a greater extent on the nature of the product. According to Buffa[1] "the specification of what to make, how to make it and how many to make become the basis of developing an integrated system of production". Major factors to be considered include adequate provision for equipments, work centres, storage space, efficient transportation system for moving the parts and products in the system, provision of service facilities both for personnel and for equipments.

1.2. PLANT DESIGN AND PLANT LAYOUT

The various production management decisions outlined encompass "plant design" and "plant layout" decisions. The following definitions will indicate the content and scope of both :

Ireson[3] defines the term "factory planning" as, "the formulation of a complete plan for the creation of goods or services. The term embraces the determination of the location, production processes, equipment, physical arrangement, provisions for personnel, offices, and all functions that are necessary to the completion of the goods". The term "factory" is used synonymously with plant.

Richman[5] defines plant design as "the overall design of an enterprise". Moore[4] has elaborated this concept. He is of the view that plant design takes into consideration the origin of the enterprise, the planning of finance, the plant location and all the planning necessary for the effective overall design of an enterprise.

It is implied from the above definitions that the content and scope of "factory planning" and "plant design" are identical.

Plant layout is easily distinguished for its content and scope, from those of the broader area of "plant design" or "factory planning" as evident from the following definitions.

According to Ireson[3] "Plant layout is the analysis and proposal for the physical arrangement of the physical facilities after the decision on the site, production processes and equipment has been made. This is a more restricted term than factory planning. It is not limited to the process of determining the arrangement of a given number of machines within a department by means of templates or models, as is often erroneously believed".

Moore[4] defines plant layout as, "a plan of or the act of planning an optimum arrangement of industrial facilities, including personnel, operating equipment, storage space, material handling equipment and all other supporting services, along with the design of best structure to contain these facilities".

Ritzman[6] defines plant layout as, "the arrangement of centres to meet a firm's production requirements economically". Economic centres can be machines, groups of machines, departments, storage areas, material handling systems, or other types of supporting service systems.

In the literature, the topic of plant layout is also dealt with under various other names : facilities planning, facilities design, layout planning and facility layout and location. For example Wilson[8] defines facilities planning as, "the synthesis of physical equipment and structures, human elements, and communication means, into an integrated system for efficiently furnishing designated services, or manufacturing specified products".

Francies and White[2] use the more general term of facility layout and location. Thye state, "In the case of the facility layout problem we seek the best layout design ; in solving the facility location problem we wish to find the optimum arrangement (design) of facilities".

Reference has also been made to "plant design and layout" in the definition of industrial engineering adopted by the American Institute of Industrial Engineering which reads :

Industrial engineering is concerned with the design, improvement, and installation of integrated systems of men, materials and equipment; drawing upon specialized knowledge and skill in the mathematical, physical, and social sciences together with the principles and methods of engineering analysis and design, to specify, predict, and evaluate the results to be obtained from such systems.

Plant design and layout is, thus concerned with the design and installation of systems of men, materials, and equipment.

From the above definitions it is obvious that, scope and content of factory planning or plant design are much broader compared to those of plant layout, which is concerned primarily with the physical arrangement of facilities.

The plant layout problem, though comparatively limited in scope and content, encompasses a variety of interesting and challenging optimization decisions. Plant layout problems arise due to a variety of reasons including : changes in the product design, addition or deletion of machines, changes in the demand for the product, changes in the process, decision to build a new plant etc.

Decisions on plant layout, however, significantly, affect the efficient operation of production systems, leading among other benefits, to :

(i) Minimizing the overall production time

(ii) Utilizing the space effectively

(iii) Providing for employee convenience and safety

(iv) Minimizing material handling cost.

However, because of the complex interaction between numerous factors and the essentially combinatorial characteristics, the problem has defined optimum solution by a computationally feasible procedure, though, a number of suboptimal procedures are available, from various disciplines : industrial engineering, computer science, economics, mathematics.

This thesis presents some approaches for design and evaluation of layouts.

Application potentiality of traditional as well as more sophisticated computerized approaches are identified through suitable case studies.

The importance of simple empirical methods for balancing assembly lines - an important area in plant design is emphasized by means of an extensive survey of theory and practice in the area of line balancing.

Various aspects of assembly line design are also considered and presented through studies on live industrial problems.

1.3. OVERVIEW OF THE THESIS

Chapter 2 presents a summary and appraisal of existing plant layout models. Particular emphasis is given to their theoretical foundations, strengths and weaknesses. The available techniques have been divided into optimal, heuristic and empirical types. Techniques belonging to the last two categories are increasingly used in practice.

In Chapter 3 a simple and efficient method is presented, for obtaining near optimal solutions to the problem of assigning facilities to locations. Problems of reasonable size can be solved manually. The method proposed can accommodate various constraints.

The plant layout problem being combinatorial in nature, there are n! feasible solutions for problems involving n facilities. These n! assignments can be represented by statistical distributions. Estimation of parameters for such distributions assists the layout analyst in evaluating various layout alternatives. Estimation of variability of such distributions is the subject of Chapter 4.

Recent research on plant layout has focused on the development of computer programs for assisting the layout planner in generating alternative layout designs. This process is referred to as "computerized layout planning". Chapter 5 attempts an objective evaluation of some promising computerized algorithms so that each approach can be used in the most effective way.

Chapter 6 presents a case study involving design of a new layout for an engineering industry. Various approaches starting from the intuitive one to the more recent graph-theoretic approaches are utilized for constructing layouts which are further improved by computerized algorithms. Suitability of subjective and intuitive approaches in certain situations is emphasized.

Assembly line balancing forms one of the important problems associated with the design of production flow - line systems. Chapter 7 is devoted to a brief review of research effort spent in developing various assembly line balancing techniques. The extent to which the formalized line balancing methods are used in practice, is also outlined. The gap between theory and practice of line balancing is identified and possible causes for the gap are discussed.

Often due to increasing variety of products manufactured, it is not possible to have one line exclusively for manufacturing each item. This leads to manufacture of more than one product (or model) on one line. One such multimodel assembly situation is discussed in Chapter 8 which presents a case study involving the design of a five-model assembly line. Existing methodology available in literature are applied in order to arrive at various design decisions.

Realistic assembly line situations involve variable performance times. A case study involving the assembly line balancing, in an electronic industry, for variable work element times, is presented in Chapter 9. Deterministic line balancing methods are used to obtain balances which are further improved by stochastic smoothing techniques. The effect of various parameters on the final balances is investigated.

Chapter 10 is set aside for the broad summary and conclusions derived from this study. The first part of this chapter is devoted to a brief summary and overall conclusions from the studies. The second part outlines some promising directions for further research.