

RETRACTED: Reengineering the Layout: A CMS Methodological Approach

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RETRACTED: ABSTRACT

Presently, most of the companies have combination of process and product layout. Cellular manufacturing is a place where company has established one or more manufacturing cells. Due to competition, Automobile industries are changing existing plant layout to "Cellular Layout" in which manufacturing process is carried out by proper arrangement of machines. This research paper aims at the optimization of cellular manufacturing layout using: cell formation stage, cell layout stage. In the first stage, a heuristic based upon the material flow is developed, which allows the machines to be clustered more naturally. In the second stage, a genetic algorithm is used to optimize the machine layout within each cell, in which a previously defined material handling system is provided. This representation allows the design of the layout and aisle-structure simultaneously, and can be converted into a string representation adaptable by a genetic algorithm for optimization. The number of aisles in the optimized aisle-structure is also minimized. A computational experiment was carried out based upon solving three problems from the literature. The results showed that cell configuration and layout planning should be considered simultaneously. Finally, an outline of an integrated design method for whole system optimization is provided.

KEYWORDS: CMS Layout, Design Optimization, Reengineering

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INTRODUCTION

In the last decade of this century, manufacturing companies all over the world face stiffer competition than ever before and consumers tend to pursue more diversified products and higher quality. As product life cycles shorten, mass production techniques have been found to be inflexible for meeting orders which are increasingly small in size, large in variety and tight in deadlines to meet current market requirements. As the ability to respond quickly to changing market requirements is becoming more important, flexible manufacturing systems (FMS) and cellular manufacturing systems (CMS) provide an opportunity to adjust to these changes. FMS and CMS are two applications of manufacturing systems and are important modern techniques in advanced manufacturing.

MANUFACTURING SYSTEMS

Introducing a product into the market generally needs the following stages. Firstly, there is the requirement for a demand for the products by consumers. Secondly, the product needs to be carefully designed to fulfill the requirements of the consumers. Next, naturally occurring or artificial raw materials are changed to the products according to the design. Then, the products are sent to consumers. Finally, services for the maintenance of product are sometimes necessary to ensure

satisfactory use of the product. The objective of design and manufacturing is to provide low-price, quality products to meet customers' requirements. A beneficial cycle, in which consumers obtain the products they want, while merchants, designers and manufacturers make profits, is to everybody's advantage. In short, manufacturing is a production procedure that converts raw materials into useful products.

Accordingly, a manufacturing system can be defined as a production system whose function is to convert raw materials into desired products [1], [2], [3]. A manufacturing procedure converting raw materials into final products can be further divided into sub-operations which produce parts, subassemblies, etc. An operation can be defined as a production procedure covering a number of process stages. For example, a single operation can be regarded as producing a part in a manufacturing cell; cutting a feature on an individual machine, or even just a step in assembling or packaging, depending on the point of view at the manufacturing system. According to the layout of facilities, manufacturing systems can be classified generally into three categories, functional manufacturing systems, mass production systems and flexible manufacturing systems or cellular manufacturing systems.

A. Functional Manufacturing Systems

A functional manufacturing system, which may also be known as a job shop, usually pools the machines of the same type together and product flows according to the process sequences. In a job shop, the types of machine tools are general and flexible enough to meet a variety of product needs. Among the pool of the machines of the same type, loading balance can be achieved without much effort and can be used to eliminate the restriction or impact of a bottleneck machine. However, as a trade-off, the material flow in a job shop is frequently complex as shown in Figure 1.[4].

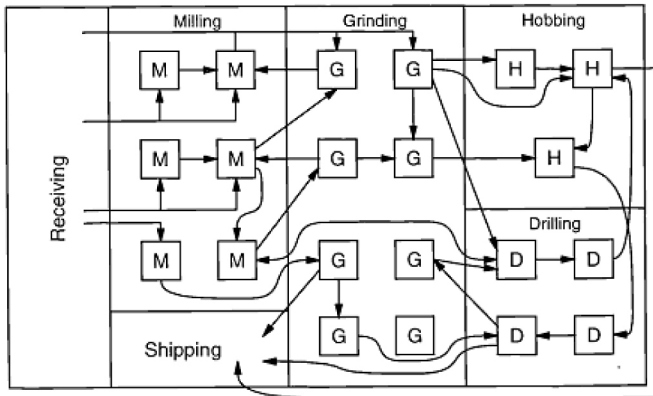


Figure 1. Job shop: Jumbled flow

B. Mass Production Systems

In a mass production system, each product flows along a line in which most of machines are dedicated to a certain type of product, which dominates the flow to achieve the lowest material handling cost and highest productivity. Because of the simple material flow and the use of dedicated machines, this system can only accommodate little or no product variation and therefore, it has little flexibility to adapt to changing markets.

C. Flexible Manufacturing Systems

A flexible manufacturing system is defined as a production system which typically consists of a set of identical and/or complementary numerically controlled machines which are connected through an automated transportation system[5]. Flexible manufacturing systems are sometimes known as Computer Integrated Manufacturing Systems (CIMS). In this thesis, the term flexible manufacturing system can be regarded as a wider definition in which some of the machines or transport in the system may be operated manually.

FMS can offer a number of advantages for manufacturers:

- Flexibility within a family of parts.
- Random feeding of parts.
- Simultaneous production of different parts.
- Decreased set-up times.
- More efficient machine usage.
- Decreased direct and indirect labours costs.

- Low work in progress (WIP).

D. Cellular Manufacturing Systems

A Cellular manufacturing system is a manufacturing system based on groups of processes, people and machines to produce a specific family of products with similar manufacturing characteristics [6]. In a cellular manufacturing system, each cell may perform as an FMS. An illustration of a cellular manufacturing system is given in Figure 2.

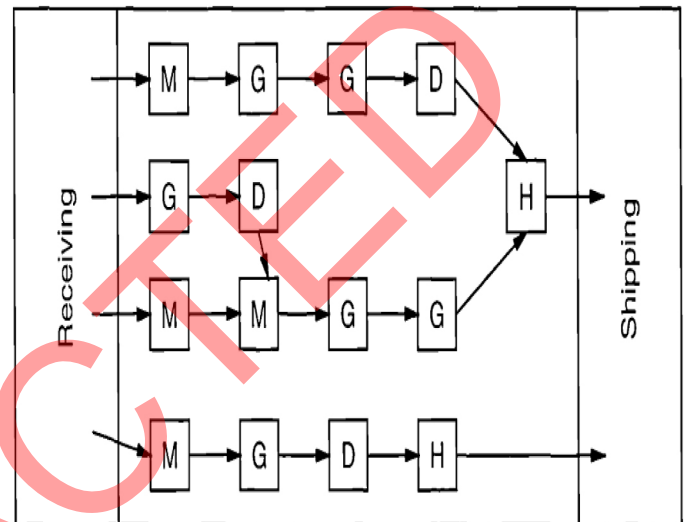


Figure 2. Families of parts and manufacturing cells: organized flow

A cellular manufacturing system could consist of independent cells, between which there is no material flow, or hybrid cells, in which shared machines are allowed.

The benefits of cellular manufacturing include :

- Reduction of material handling cost.
- Organized material flow.
- Reduction of work-in-progress inventory.
- Reduction of setup time.
- Better lead times and fast response.
- Improvement of resource utilization.
- Improvement of the productivity of the systems.
- Improved quality.
- Improved customer service [7].

In general, a mass production system is most appropriate for parts with high demand and low variety. A functional production system is best suited for a product mix characterized by high variety and low demand, while a cellular manufacturing system is in the middle and has more flexibility to adapt to product variety and demand. A comparison of different kinds of manufacturing systems based on their production rate and production variety is illustrated as in Figure 3 gave a recent review and analysis of the performance comparison between functional and cellular manufacturing systems [8,9].

review reveals contradictory results from previous simulation and empirical studies and shows the complexity of the evaluation and the simulation of the systems.

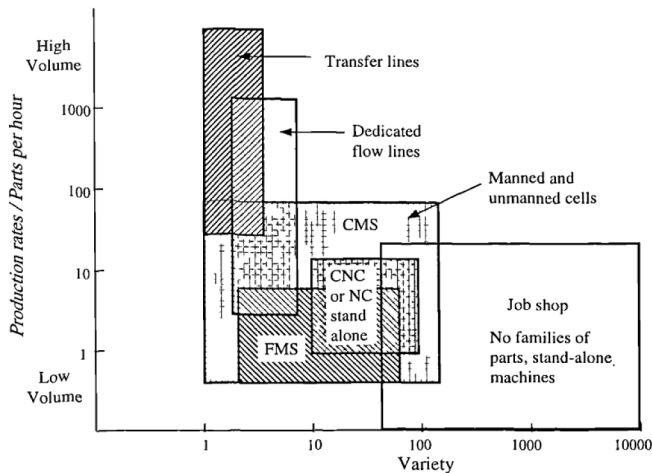


Figure 3. Comparison of different kinds of manufacturing systems

DESIGNING CELLULAR MANUFACTURING SYSTEMS

There are two kinds of manufacturing system design problems, the green field problem and the brown field problem. In a brown field problem, the factory already exists. The existing shop floor, machines, transport and layout should be taken into consideration in the design of the new system. Thus, the design in a brown field site can be considered to be just a 'renewal' of the existing system. On the other hand, there are no such constraints in a green field layout and designers are free to select the most suitable machines, transport and layout for the factory. More decisions have to be made in solving the green field problem. Decisions that should be made in solving green field design problems and may sometimes be required in a brown field design are discussed below.

A. Job Assignment Problem

To produce a product, each operation to be carried out on the product has to be assigned to a certain type of machine. These operations and the operation sequences are decided by process planning after the product design stage. The assignment may have a number of choices. For instance, a hole in a part could be performed on a drilling machine, a milling machine, a machining centre, a boring machine or sometimes a lathe. This problem is known as the job machine assignment problem or machine assignment problem [10], [11], [12]. This decision should consider the investment and running cost of the machine type, the location of the machine tool, the scheduling of the machine and the loading balance among the other machines. In a green field design, the job assignment problem should be solved simultaneously with the cell formation problem and layout problem.

B. Cell Formation Problem

Cell formation assigns machines or machine types to cells in order to simplify the flow and minimize the material handling cost. The decisions include how many cells are in the plant, also which and how many machines of a machine type should be clustered into a machine cell. As in the case of the job assignment problem, the investment and running cost of each machine type, the location of the machine, the loading balances among the machines or cells, the scheduling of parts at each machine and the tooling within cells should be taken into account. The flexibility of cells may also need to be considered corresponding to the policy of the company.

C. Layout Planning Problem

Based upon cell formation, layout planning decides the dimensions of the plant floor and location of the cells, machines and auxiliaries. The objective of layout planning is mainly the reduction of material handling cost. The problem is solved in conjunction with transportation system design, product planning and scheduling, because it should leave spaces for inventory and transport on the plant floor. Not only are the above problems highly interactive with layout planning, the layout problem itself is also complicated and difficult. The following is a description of the layout problem given by Demes [13]. "Layout design tackles many complex issues that typically arise in the design of artifacts that must satisfy spatial and functional constraints. A potentially infinite number of location and orientation combinations are available for placing any single object. In each combination design objects interact through their shapes, sizes, and their spatial or topological relations. Layout design decisions must simultaneously satisfy global requirements (e.g., use of space) and local requirements (e.g., adjacencies between pairs of objects). An acceptable spatial arrangement often exhibits a complex pattern of trade-offs. For these reasons, an exploration of the structure of the layout task and a search for candidate solutions is required. Due to cognitive limitation, human designers have limited capability for making systematic explorations of alternative arrangements. This shortcoming in human performance has motivated numerous attempts to apply computational methods to layout. What is desired is a structured method for producing alternatives, each of which embodies trade-offs that can be understood and justified." This thesis is a response to the challenge described in the concluding sentence.

D. Transportation System Design Problem

In order to transfer products between machines or inventories, a proper transportation system or systems should be carefully designed to match the machine layout. The design includes the arrangement of the aisle structure for the movement of parts/products and workers and the selection of the types of the transports, their speed and loading ability. The production management policy, such as just in time (HT), has a strong impact on the transportation system design.