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Reflections on Hybrid Production Layouts

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Hybrid layouts have gained popularity among manufacturers. Hybrid layouts adapt or combine some aspects of the basic production layouts such as product and process. Manufacturers perceive that combined manufacturing benefits could be achieved by adopting the concept of a hybrid layout. However, most of these hybrid layouts as discussed in the textbooks or research articles are ideal theoretical models which may not be suitable for manufacturers to adopt and apply in the practical environments. This paper is to explain that hybrid layout production is theoretically ideal as reported, but may not be appropriate to use and apply in a practical world. This paper explained that the implementation of the hybrid production layouts should be configured according to the manufacturer's objectives and competitive priority principles.

1. Introduction

Layout design in manufacturing refers to the physical configuration of departments, equipment, and storage facilities. The ultimate achievement of having a layout design is to facilitate a smooth flow of material, work, and information through the production system. Layout design is especially important (Stevenson 2012) because it can be a complicated and costly process to alter once the layout design is installed due to significant investment on machines or equipment. The three classical layouts are product, process, and fixed-position. Product layouts organize activities in a line according to the sequence of operations that need to be performed to assemble a particular product. Process layout groups workstations together according to the process or functions being performed. Hybrid layout is a combination layout of two or more of the classical layouts. The hybrid layout is believed to be able to achieve combined manufacturing benefits that could be derived from these classical layouts. Hybrid layout is perceived to be flexible yet efficient when formed. The hybrid layouts that are commonly practiced are the cellular layouts, flexible manufacturing systems, and mixed-model assembly lines. The cellular layout is a hybrid layout that is reported to gain manufacturing benefits in efficiency and flexibility. It combines the flexibility of a process layout with the efficiency of a product layout. The need of designing different type of layouts can be recognized by product volume, product similarity, product routing sequence, and machine utilization. According to these measures, the products are in need of dividing into different groups for different combination layouts such as the hybrid production layouts. Many researchers have developed methods and algorithms based on a coding scheme of part geometry similarity or similarity of the production routing sequence to design the hybrid production layout. However, these methods and algorithms tend to neglect the company's strategic competitive priorities aspects into the design of a hybrid production layout.

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This paper is to explain the hybrid layout production is theoretically ideal as reported, but may not necessarily be applicable in the real world's practical manufacturing arena. Previous researches in this area address the formation of hybrid layout through a coding scheme of part geometry similarity or similarity of the production routing sequence. This paper will explain the design of a hybrid production layout should be configured according to the company's manufacturing competitive priorities and advantages. Section 2 discusses about the researches conducted in the areas of grouping machine cells and handling of bottleneck machines for facility layout in hybrid production. Section 3 examines the major practical considerations needed for organizations to configure the hybrid layout production. Section 4 suggested the facility layout for the hybrid production should be configured according to the organization's focus, strategic objectives, system performance measures and competitive advantage in the marketplace. Finally, we conclude this paper in Section 5.

2. Literature Review

Hybrid production layout combines both process layout and product layout to realize production benefits of efficiency and flexibility. The layout is based on the concept of group technology that requires dissimilar machines grouped into a cell to process a group of parts termed as the part family. A part family is a group of parts that can be produced by the same sequence of machining operations because of similarity in design and processing attributes. The dissimilar machines are termed as the machine family that will be dedicated to process the part family. This way of processing and producing manufacturing parts is also known as the cellular manufacturing systems. The layout of the cell would be designed with the best configuration so that manufacturing efficiency and effectiveness benefits would be achieved. The layout is considered to achieve many manufacturing benefits and efficiencies. The benefits reported include work-in-process (WIP) reduction, lead time or throughput time reduction, productivity improvement, quality improvement, better scheduling, simplicity in tool control, enhanced flexibility and visibility, and better teamwork and communication. Frasera, Harrisa & Luongb (2007), Raafat (2002) reported extensively how manufacturing benefits could be achieved by applying the cellular layout manufacturing systems.

To implement the hybrid production layout is to be able to group dissimilar machines into families through the cell formation process so that machines and parts families could be identified efficiently to configure the layout to produce goods. There were many grouping methodologies (cell formation) developed since 1970. The leading methodologies to grouping machines into machine-cells and parts into part families are:

- Machine-component Similarity Group Analysis (Yin & Yasusa 2006), (Gupta & Seifoddini 1990),
- Coding and Classifications (Chandrasekharan & Rajagoplan 1986), (Dunlap & Hirlenger 1983),
- Knowledge-Based (Ang, McDevitt & Jamshidi 1994), (ElMaraghy & Gu 1988),
- Fuzzy Theory with Similarity Coefficient and Mathematical programming (Saxena & Jain 2011), (Defersha & Chen 2006),
- Simulation (Masmoudi & Hachicha 2013), (Hachicha, Masmoudi & Haddar 2007),
- Heuristics & Algorithms (Liu et al. 2010), (Pillai & Subbarao 2008), (Cheng, Goh & Lee 2001), (Ang & Hegji 1997), and
- Multi-Criteria (Arunkumar, Karunamoorthy & Muthukumar 2011), (Mansouri, Moattar Husseini & Newman 2000).

The machine clusters are formed on the products that are produced in common between the machines. The goal of forming machine clusters is to process products that have functional similarity to maximize the efficiency of the production and layout. Machine cluster formation involves combining the dissimilar machines together and dedicating them to manufacture a group of product which can be performed by (i) forming machine cells and deducing part families to the machine cells, (ii) forming part families and deducing machines based on processing information and (iii) forming part families and machine cells simultaneously.

Comprehensive reviews for the cell formation design problem and the solution approaches can be found in Dasa, Lashkari & Sengupta (2007), Fraser, Harris & Luong (2007), and Raafat (2002). The evaluation and studies pertaining to cellular manufacturing design and system performance such as the examining of the impact of changes in part mix size on cell queuing time and the impact of batch size on manufacturing cell flow time performance for a heterogeneous part mix were studied by Kekre (1987), Deane & Yang (1992). In the situation of handling of exceptional parts and machines in CMS, (Kern & Wei (1991), Chow & Hawaleshka (1992), Tsai, Chu & Barta (1997), and Won (2000) studied the best way to resolve the exceptional machines and parts issues through better grouping or improved algorithms. Shafer, Kern & Wei (1992) used mathematical programming to resolve bottleneck machines and parts problems. Ang (2000), Seifoddini (1989), Seifoddini (1989), Kusiak & Chow (1987) presented a cost-based duplication procedure and cost based algorithm to resolve the handling of the exceptional machines and parts in cellular manufacturing systems.

3. Methodology

Previous researches in this area address the formation of hybrid layout through a coding scheme of part geometry similarity or similarity of the production routing sequence. These methods and algorithms neglected to build the practical manufacturing practices and considerations into the design. These cell formation methods and algorithms assumed little or no set up time between successive jobs within the manufacturing cell. These methods and algorithms failed to include job scheduling difficulty considerations. The processing time and cycle time at each workstation within the cell are normally assumed to be balanced. Also, the machinery equipment capacity constraints such as maintenance time and downtime time were never incorporated into design consideration. In general, many of these cell formation methods and algorithms that are reported in the literature review can only be applicable in a non-practical ideal hybrid layout production application. In this study, we found out that hybrid production layout can differ considerably in size, in automation, and in the variety of parts processed. To apply the hybrid production layout, companies would need to consider these major practical considerations and issues such as:

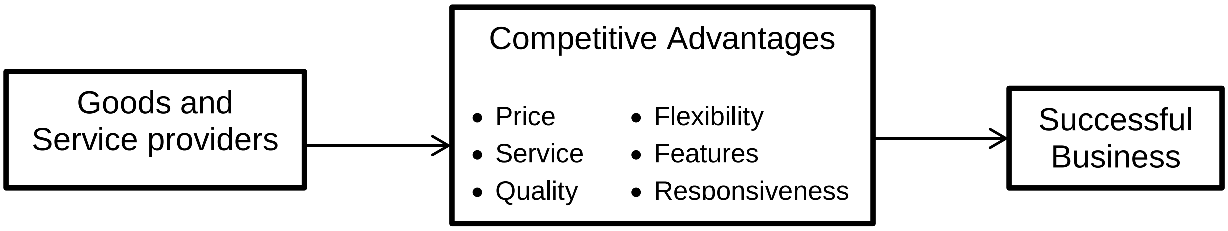
1. Using the best cell formation algorithms to identify machine and part families.
2. Determining the optimum cell evaluating a small number of large cells versus a large number of small cells.
3. Deciding on how to attain the best system performance measures through flow time balancing, resource utilization, and other operational factors to achieve efficiency and effectiveness.
4. Deciding on how cells are placed in relation to each other so that intercellular movements to transport work in process parts could be minimized.

In general, many of these hybrid production layout cell formation methods and algorithms that are reported in the literature review can only be applicable in a non-practical ideal hybrid layout production application. In section 4, Figure 2 will demonstrate the hybrid production layout design should be driven by the manufacturer's strategic objectives and competitive priority analysis to the cell formation design decision. In this study, we explained that hybrid production layouts should not just be based on the part geometry coding scheme similarity, routing processing sequence similarity, or minimizing the numbers of exceptional machines or parts.

4. Results and Analysis

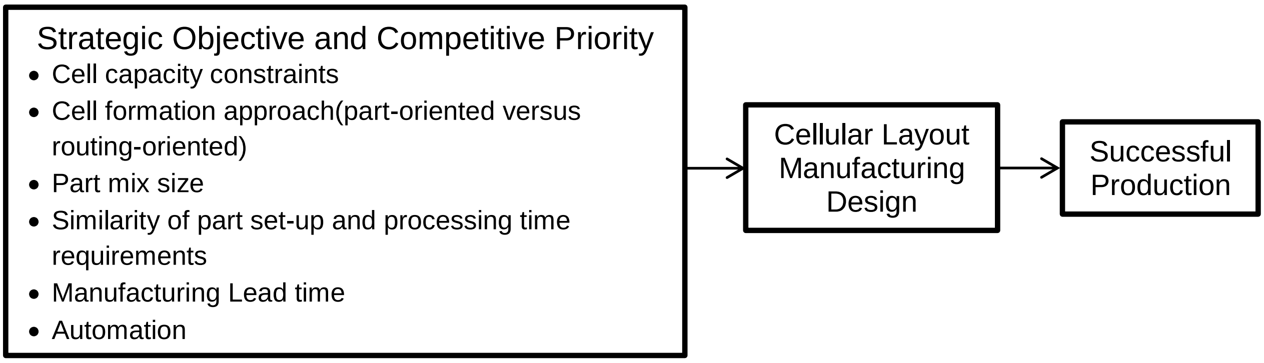
In this competitive world, any goods and services providers would need to possess an advantage over their competitors if the providers want to start a successful business or stay in business. Competitive advantage can be attributed to one or a combination of the factors such as price, service, quality, location, or imbedded customer base. If the providers are able to perform well in at least one of these factors, they are more likely to succeed. The following Figure 1 shows goods and services providers would need to face these complex and dynamic competitive advantages.

Figure 1: Business Competitive Advantages



In a similar fashions, manufacturers when adapting to the hybrid production layout concepts to produce goods should assimilate the business advantages concepts as illustrated in Figure 1. The manufacturer's critical hybrid production layout design decisions and considerations should be more directly related to the firm's competitive priorities and long-term strategic objectives. The cell formation techniques and how the layout should be configured must be related to a firm's manufacturing focus, strategic objectives, system performance measures and competitive advantage in the marketplace. The hybrid layout production processing requirements and its layout could not simply be based on a coding scheme of partial geometry similarity, similarity of the production routing sequence, or a minimum number of exceptional parts and machines existence. As reported in the literature reviews, a majority of these developed algorithms and methods suggested that cellular manufacturing cell design should address the tactical treatment rather than a strategic analysis. Figure 2 demonstrates that the hybrid production layout design should be driven by the manufacturer's strategic objectives and competitive priority analysis to the cell formation design decision. These strategic objectives and competitive priority considerations should include design factors such as cell capacity constraints, stochastic job arrivals, characteristics of part mix, and the effects of set-up time reduction.

Figure 2: Strategic Objectives Analysis in Hybrid Layout Production



5. Conclusions

In this study, we explained that hybrid production layouts should not just be based on the part geometry coding scheme similarity, routing processing sequence similarity, or minimizing the numbers of exceptional machines or parts. Due to the fact that the hybrid production layouts can differ considerably in size, in automation, and in the variety of parts processed. We believe that in the case of designing hybrid production layout, it is particularly important to have structural properties and company's manufacturing priorities competitive policies.

The study explained that when designing a competitive hybrid production facility, company would need to establish policies on how to select the best cell formation algorithms to identify machine and part families, decide on the optimum cell size requirements, decide on how to attain the best system performance measures through flow time balancing, resource utilization, and other operational factors to achieve efficiency and effectiveness, and decide on how cells are placed in relation to each other so that intercellular movements to transport work in process parts could be minimized. The study also found out that the complexity of designing an optimal hybrid production layout is such that it is very unlikely for any "general" solution procedure to be computationally feasible; a more promising direction is that of seeking structural policies that should include the manufacturer's manufacturing focus, strategic objectives, system performance measures, and marketplace competitive advantage.

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