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Impact on Improving Facility Layout Design on Company System Performance

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ABSTRACT: Layout design is one of the significant roles on company performance and work-cells layout is one of the thriving methods. Therefore, many researchers have point out the advantages of cellular manufacturing system. However, in this study, the problems of cellular manufacturing will be point out according to company performance: work in process lead time, worker performance and company productivity.
Keywords: facility layout, work-cells layout, cellular manufacturing system, company productivity.

INTRODUCTION

In recent years, the manufacturing and service industries have significant developments. Facility layout designs have a significant impact on system performance: productivity, manufacturing handling cost and work in process lead time. Organization can achieve a strategy that supports differentiation and low cost of competitive advantages by having an efficient and effective layout that determines an efficient of long-run operations [1]. Sundereh S. H [2] defined facilities as buildings where produce a tangible product or provide a service at lower cost and high quality by utilize materials, machines, and other resources that use. Facility layout is an arrangement of everything needed for production of goods or delivery of services [3]. To achieve an effective facility layout design, few factors should be considered. These includes optimal physical arrangement of departments by utilize space, improve flow of information, improve employee morale and safer working conditions, improve customer interactions and flexibility of the layout.

Work-cells layout has steadily gained in popularity over the past few decades. The idea of work-cells was first present by R.E. Flanders in 1925 and has further evolved by Jay and Barry [4]. Jay and Barry have stated out the five main advantages of work- cell which included tasks are grouped, few workers are needed, workers can reach more areas, work area can be more efficiency and communication between workers is enhanced. U-shaped work-cell is one of the popular examples of work-cells layout. According to Seyed [5], work-cell is an arrangement of machines and personnel that focuses on making a single product or family of products. Typically it has 3 -12 peoples and 5 – 15 workstations in a compact arrangement. Cellular Manufacturing System (CMS) is a concept of performing all necessary operations in a work cells. In CMS, parts that have similar manufacturing requirements are grouped into part families, and machines are organized as machine cells [6].

FACILITY LAYOUT DESIGN

Facility layout problem aimed to find out the minimum distance of flow between two departments. Quadratic assignment problem (QAP) only considers the problem of assign equal-sized department and not applicable with unequal-sized. Montreuil introduced a mixed integer programming (MIP) model for the facility layout problem which used as a basis for several rounding heuristics, but Montreuil's model only has 0 – 1 variables which cannot solve unequal-sized problem optimally. Therefore, Russell, Venkat and Pamela [7] redefining Montreuil variables and tightening the department area constrains by proposed valid inequalities known as –Eq. (1)‖ which included –Eq. (1) =‖ and –Eq. (1) ≥‖ to increase the range department sizes and ensure problem solve optimality. As a result Eq. (1) performed much better in optimizing the facility layout design problem solving.

Eq. (1):
$$\sum_{s=x}^{y}(z_{ij}^{s}+z_{ji}^{s}) \geqslant 1 \quad \forall j > i$$

z_ij^s /z_ji^s = binary relative location variables, i and j were two different departments
The upside down A is the proposed surrogate area constraint since there have no departments can overlap in a valid layout [7].
Amine, Henri and Sonia were using a tree diagram to represent the layout problems which depending on few factors as: the workshop characteristics, what is the problem addressed and the approaches used to solve it [3]. They believed that this tree representation can be improved in future research works. In-depth, workshop characteristics have been divided into six parts: the production variety and the volume, the material handling system chosen, the different possible flows allowed for parts, the number of flows on which machines can be assigned, the facility shape and pick-up and drop-off locations. Four type of layouts have been pointing out which included fixed product layout that suited for manufacturing large size products, process layout that groups facilities with similar functions suited for wide variety of product, product layout for high productivity and low variety of product and cellular layout that machines are grouped into cells, to process families of similar parts. Besides, two facility shapes are distinguished: regular and irregular. Manufacturing cost that has a good arrangement of handling device might reduce for 10 – 30% [8]. Devise and Pierreval believed the type of materials handling device determines the pattern to be used for the layout of machine [9]. Types of materials handling can distinguish as single row layout, multi-rows layout, loop layout and open field layout [10]. Limitation of available horizontal space creates a need to use a vertical dimension of the workshop with the development of multi-floor layout. In addition, manufacturing plants must be able to respond quickly to the dynamic environment; therefore, the idea of dynamic layout problems has been introduced. Two models are generally used on formulate the problem: graph theory and neural network. Several types of optimization approaches have been proposed by: exact methods which used to solve the problem of placing facilities within a given rectangular

available area and approximated approaches. Finally, they believe that there is still research needed for solving the different problems involved in the design of the workshop.

According to journal's literature review that done by Dhamodharan, Sev and Grier, they believed the recent and the only factor to determine the effectiveness of layout is materials handling cost (MHC). However, most of the studies have considered materials handling cost only as the performance factor. Besides the performance of the layout, empty travel of material handling equipment, layout flexibility and area utilization also have a significant impact on the effectiveness of layout design. Therefore, Dhamodharan, Sev and Grier have developed three layout effectiveness factors in their research: facilities layout flexibility (FLF), production area utilization (PAU) and closeness gap (CG). By developed these factors, they hope to minimizing the manual handling cost, improving flexibility for arrangement and operation, utilizing the available area more effectively and minimizing overall production time. FLF defined as the ability of layout to effectively withstand various changes that arise from unceasing transformations in customers' requirement and the enterprises' internal disturbances. Nowadays, manufacturing enterprise should respond quickly with the uncertainty and changes in manufacturing environment. Yet, the flexibility factors cannot be measured precisely and modeled mathematically. Productive area utilization (PAU) involves the allocating the area required at appropriate location for various needed activities. The most importance part of this research was discuss about closeness gap (CG) where it measures the extent to which the existing layout from the best theoretical layout in terms of closeness value. CG has measured in two levels: intra-functional level and inter-functional level. The flow among facilities within a department is intra-functional measurement while the flow among department within an enterprise is inter-functional level. They have also qualitatively justified the criticality of these factors the measurement of layout effectiveness. From there research, they recommended the current work can be convert from performance index to cost functions, which is self-justification factor in decision making process. [10]

Reconfiguration layout problem is needed when there have changes in product mix and volume. The main factors of reconfiguration the layout problem is to minimize materials handling cost and ensure equipment can suit to new production mix and volume. Besides materials handling cost, relocations cost and stochastic performance measurement also needed to take in consider for reconfiguration layout problem. Minimize part cycle times and work in process inventory, reduce product lead time and rapidly response to changing needs and opportunities were the examples of stochastic performance. There have three physical layers as a reference model that relevant to the layout problem: product mix, machine types and locations on shop floor. Manufacturing system Performance Analyzer (MPA) is one of the models to estimate the stochastic performance measures of layout. Four phase approach have been discussed for design and analysis reconfiguration of layouts which included generate candidate layouts, estimate performance measures of layouts, determine layout to be used and refine selected layout. Meng and Heragu described that MPA is the most accurate and comprehensive analytical model used to evaluate the performance of layout. According to Meng, Heragu and Zijm (2004), MPA fits well into the reconfigurable layout framework [12].

WORK-CELL LAYOUT AND CELLUARMANUFACTURING SYSTEM

Work-cell layout is much more suitable for manufacturing that produce low variety and high volume of product. Transformation of layout design to work-cell layout may increase the manufacturing efficiency; however, it is near impossible to restructure the overall layout of the company. According to Amine, Henri and Sonia, 50 % of facility's total expenses able to be reduce by having a good placement of facility [3]. Work-cell layout may drive down the labour cost, increase the productivity and efficiency of worker, provided a better spaces for worker to communicate, decrease the amount of floor place needed and increases the machine utilization. Although rebuilding an entirely new facility may not be feasible, company still need to optimal the efficiency of production and service in order to remain competitive in market by redesign the work-cells and others section of the facility such as storage [5].

Cellular Management System (CMS) and work-cell is a central element of Lean Production. CMS is an approach to enable both, flow production and volume flexibility in machining. Joachim, Sven and Stefan using the example of milling, focus on the identifying relevant performance indicators to evaluate the economic fields of application of CMS. Therefore, an identification of application-criteria for an economic use of CMS is targeted. As a result, CMS enable an efficient and economic use to optimum both machine tools and operators. They advocated more activities should identify the economic boundaries to enhance future fields of application. To maximize the performance, few challenges will be encounter during the investigation for the next few years: quantitative evaluation of flexibility improvements, line balancing of machining process and the time taken for change-over procedures [13].

Applying work-cells layout will transform the manufacturing operating system to cellular manufacturing system (CMS) which increases the competitive advantage of company. Manufacturing firms aim to take the advantage of increasing in throughput, leading to product quality and customer satisfaction. According to Wemmerlov and Johnson, manufacturing firms who embrace modern philosophies such as Just-in-Time (JIT), total quality management (TQM) and time-based competition (TBC) use the principles of CMS [14]. Godfrey categories six major classifications of approaches to cell formation: array-based clustering, similarity coefficient, mathematical programming, graph and network, heuristic and combinatorial optimization. He believed similarity order clustering (SOC) algorithm which using the similarity coefficient method (SCM) to identify the relationships between pairs of machines is very useful, simple and effective to cell grouping procedures. Machine processing time, setup time per batch, part batch sizes, period demand for parts and time available per machine per period were the data that needed to determine the machine utilization [15].

Similarity coefficient method (SCM) is the approaches that wisely used to utilized machine-cells formation. SCM is simple, flexible and can lend to computer implementations. When there have an improper assignment of parts families during the process of rearrange, it may clash with the objectives of CMS. Average linkages clustering method (ALC) [16] and linear cell clustering analysis (LCCA) [17] have been applied to reduce the chance of improper machine assign; however, it is not enough to ensure the assignment of component between inter-cell and intra-cell is 100% correct. David has presented an algorithm that do not based on any technique of SCM which can solve the improper part-components assignment problem, identify and minimal the production of bottleneck parts and reduce the unnecessary intercellular movements. This algorithm minimize the flow between group by concentrates on arranging parts among already-identify machine group rather than addressing the machine-grouping problem in general. David recommended practitioner on this algorithm can devote more time to find an efficient ways of handling bottleneck-parts that arise [18].

According to Arshia, Mir, Behzad and Ahmad [19] research, they consider the previous problems of array-based clustering methods and apply the idea of multiple attribute decision making (MADM) concept and technique for order preference by similarity to the ideal solution (TOPSIS) to solve the cellular manufacturing problems. The array-based clustering methods are based on the part-machine incidence matrix (PMIM). The initial problem PMIM is solve by TOPSIS and then improved by simple additive weighting (TOPSIS-IMP-SAW) and TOPSIS (TOPSIS-IMP-TOPSIS). They found that ―TOPSIS-IMP-SAW‖ method is better in solving small scale of problems while ―TOPSIS-IMP-TOPSIS‖ methods is better in solving large scale area of problems. IMP is abbreviation for improved [19].

Shahram and Napsiah [20] have proposed simulated annealing (SA) algorithm for improved layout design in cellular manufacturing systems (CMS) by comparing the computation time with benchmarked algorithm that developed by Wang, Lin and Wu [21]. SA is well-adapted in optimization of combinatorial problems. This algorithm produces solutions with less computation time and minimize both inter and intra cell manufacturing handling costs. As a result, SA algorithm produces better solutions with maximum of 0.08% error compared to 0.12% error in benchmarked algorithm. Hence, they proposed SA algorithm is better than benchmarked to solve layout problems especially when the size of problem increases.

Viviana and Harold have conducted a study of labor flexibility in cellular manufacturing systems by using simulation modeling. Two types of labor [22] flexibility are considered: inter-cell labour flexibility and intra-cell labour flexibility and they were classified depending on the operator‘s mobility. This investigation is to explore the impact that using different layout allocation strategies on system performance by clarified the types of machine-operator assignments into dedicated, shared or combined assignment. Their research has considered the concepts of workload sharing, workload balancing and the present of bottleneck operations. As a result, the higher the sharing level between operators in different labour strategies, the cell performance tends to increase. 68% of performance have improved by comparing the results of dedicated assignment and shared workload assignment. The values for measurement of balance tend to be low since operator able to perform more tasks and workloads are more leveled at high levels of sharing .

A research that focused on more practicable and complicated problems that consider the three critical issues in cellular manufacturing system (CMS): cell formation, cell layout and intracellular machined sequence have been conducted by Chang, Wu and Wu[23]. In their study, two-stage mathematical programming model and two-stage Tabu search approach have been formulated and proposed. In two-stage mathematical programing model, the first state aim to solve the cell formation problem and cell layout problem while the final solution will obtain at phase two based on the state 1 result to determine the machine layout. The proposed algorithm can produce optimal solutions within a shorten time compare with others mathematical programming approaches.

Patrick and Isidro [24]have researched in the impact of application of Cellular Manufacturing (CM) in Maintenance Repair and Overhaul (MRO) on aerospace scope. Six aerospace businesses practice MRO were evaluated and founded that the application of CM to MRO were benefits in short turn-around-times and operational performance. They concluded all the businesses achieved benefits of developed continues improvement (CI) actions and build up a strategic on competitive advantages. Delivery times have reduced, unnecessary movement was remove, waste been determined and remove and enable business wide response to changing market conditions.

CONCLUSION

Several of researches have been conducted focusing on facility layout problems: factors that represent the layout problems, methods that use to solve the facility layout problems, methods to determine the effectiveness of layout designs and impact of reconfiguration layout problem. One of the popular facility layouts that been evolved and embraced by most manufacturing and service industries is work-cells layout. Many researchers have been conducted base on work-cell layout and cellular manufacturing concept. The researcher discover the work-cell layout have improved the competitive advantages of manufacturing firms, reduced manufacturing handling cost and work in process lead time and improved labour flexibility.

These researches have focus on the importance of work-cell layout, advantages of work-cells layout and the ways to improve the work-cell layout to be more efficiency, yet there should have a clear picture on negative sides of cellular manufacturing systems and the impact on manufacturing system performance.

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