A Review of Facility Layout Selection Models in Manufacturing Organizations

Eida Nadirah Roslin, Siti Zawiah Md Dawal, Shamsuddin Ahmed

Abstract—**Facility layout design involves a very huge investment to manufacturing organizations, and each layout design selected needs to give a positive impact towards the company. However when trying to apply the best layout design that is effective, it involves a huge challenge and needs to be done carefully by all manufacturing organizations. A great deal of study had been undertaken to find optimal solutions to these facility layout problems, especially in optimizing the layout design. It has been noticed that studies on applied methods of facility layout selection is limited. This review paper will discuss about the models that have been developed in trying to solve these facility layout problems, focusing on the facility layout selection process. The future model of the facility layout selection has been proposed.**

Keywords:Facility Layout Design; Facility Layout Problem; Facility Layout Selection Model.

I. INTRODUCTION

The rapid growth of technology within the industry today has give a significant impact to the industrial and manufacturing industry especially in their engineering activities. These industrial and manufacturing companies not only face highly competitive business environment which affects their profitability but are also forced to deal in problems that unwittingly affects their facility design and engineering activities.

Facility layout design is a very huge investment to the manufacturing organizations. The expected Return On Investment (ROI) is usually long. So the decisions of expanding, consolidating or modifying existing facility layout needs to be done meticulously with a structured phased planning. However with demanding developments and competitive innovations, the right decisions that are timely would be the main aim for any manufacturing organizations.

A solution in determining the best facility layout arrangement is a key factor in solving facility layout problem that is related to layout designs. In this review paper, the author will discuss models that have been developed as a tool in solving this facility layout problem focusing on the facility layout selection based on the previous studies done.

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II. FACILITY LAYOUT PROBLEMS

Facility layout is defined as a planning process for the flow patterns of materials and people around, into, and within buildings [1]. The layout affects material flow, handling and maintenance costs, equipment use, productivity, production flexibility, management effectiveness, and even employee morale [4].

In general facility layout planning is an arrangement of space and resources in the organization and the arrangement has a great impact on the overall activities within the organization.

Determining the final placement of facilities in the plant area, is often referred to as a "facility layout problem"; it's known to have a significant impact upon manufacturing costs, work in process, lead times and productivity [2]. A good placement of facilities contributes to the overall efficiency of operations and can reduce until 50% the total operating expenses [1] as quoted by [2].

The facility layout problem is not a detached design problem. It has a relationship with other manufacturing design processes. According to [5], in the design of manufacturing layouts, minimizing material handling costs and providing a safe workplace for employees are the major considerations. The facility layout problem solution involves determining the location of machines, workstations and other facilities to achieve these six objectives:

- Minimize the material handling costs, minimize overall production time, and minimize investment in equipment between the facilities. [7] as quoted by [8], [9].
- Facilitate the traffic flow. [6]
- Increase the employee morale.[6]
- Provide the employee safety [7] as quoted by [8], [9].

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- Minimize the risk of injury to personnel and damage property. [6]
- Where necessary, provide for supervision and face-to-face communication. [6].

As mentioned earlier, facility layout problems are usually treated as a design problem. Therefore, many studies discussed optimization for a single objective, such as a minimum equipment investment cost, the maximum space utilized and / or the material handling cost incurred.

During facility layout selections or decision makings, all objectives should be considered [4]. Making decisions in order to solve problems should be constantly and continuously done by everyone within an organization. In fact it is a crucial factor that determines the daily running's of the company. So in determining the best facility layout, it also needs to be done through making calculated decisions based on inputs and criteria parallel to the needs of the organization [3]. The only difference here is that those inferences need to be done, at most times, prior to start-up of an outfit or before expanding their current facilities.

These 'design-decisions' need to be made right the first time, or else the organizations could face consequences later that might effect their efficiency, profitability or even image. As a result several models had been invented by researchers in solving the facility layout problem especially in selecting and optimizing the facility layout design. However, a model that can support the future scenario of manufacturing business need to be studied and developed. [12]

III. Studies on Facility Layout Selection Models

The facility layout problem is one of the best-studied fields in trying to achieve its goal of productivity and profitability. This problem is a strategic issue and has a significant impact on the efficiency of a manufacturing system [10] and manufacturing organization's survival.

Within the facility layout problems the major focus should be on optimizing and selecting the best layout design. Few models and methodologies have been developed in efforts to find effective ways to solve it. Some of these studies are summarized in the table 1 as follows:

TABLE 1
SUMMARIZED STUDIES ON FACILITY LAYOUT PROBLEM

NO	AUTHOR/AUTHORS	METHODOLOGY	RESULT FINDINGS
1	Multiple-attribute Decision Making Methods for Plant Layout Design Problem *(Yang and Hung 2007)*	The study used the multi-attribute decision making (MADM) approaches in solving a layout design problem.	Proposed two methods TOPSIS and fuzzy TOPSIS. It focuses on the evaluation of alternatives layout designs – considering qualitative and quantitative design criteria. The methods used to evaluate a large number of layout design alternatives in order to reduce the risk of missing a high quality solution.
2	Expert System for industrial facilities layout planning and analysis *(Kumara ,Kashyap et al. 1987)*	Using the Expert System to find the criteria in generating the alternate path in facility layout. Use five steps - problem definition, conceptualization, implementation, user interface and learning.	The main purpose of this study is to generate alternate path in facility layout planning by using the proposed criteria generated using the expert system whereby the system uses a combination of heuristics search and constrained directed reasoning, This model deals with assigning departments to areas in such manner that layout configurations with different satisfaction levels are generated. The programming language in this model is PROLOG.
3	A formulation of the integrated facility layout, product selection and process planning problem *(Askin 1986)*	Integration model for optimizing the layout design. This mathematical model was developed by using the Lagrangrian relaxation method.	An economic decisions model that being develop for the long range plan of facility layout in the manufacturing organization. The model integrates the solution for type of production selection, capacity planning, process planning and the facility layout.

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4	LayoutManager: A microcomputer-based decision support system for facilities layout *(Foulds 1997)*	Introduced a decision support system – LayoutManager which is designed to address issues concerning block plan design that commonly occur within a particular computer hardware manufacturing plant. The system is written in Pascal, within the Microsoft Windows environment.	LayoutManager was designed to assist planners in every step of the layout design process. It is the system in optimizing the layout designs by providing powerful tools to create layout plans, choose between plans, generate alternative plans, and to assess alternative plans with respect to productivity criteria of the choice.
5	Fuzzy decision support system for manufacturing facilities layout planning *(Deb and Bhattachanyya 2005)*	Introduce a decision support system based on multifactor fuzzy inference system (FIS) for the development of facility layout with fixed pickup/drop-off points. The proposed methodology is coded in C^+ language.	The fuzzy decision support system presented in this paper is an effective way to handle inexact and vague data. The algorithm searches several candidate points with different orientation of incoming machine blocks in order to minimize flow cost, dead space and area required for the development of layout. The present work simply demonstrates the potential applicability of fuzzy set theory and offers a systematic guidance to the decision makers in planning manufacturing facilities layout under fuzzy environment.
6	Layout design using the analytic hierarchy process *(Cambron and Evans)*	This study introduced the Analytic Hierarchy Process (AHP) as a methodology for modeling unstructured problems in selecting the facility layout.	The analytic hierarchy process shows promise as an effective tool in selecting from a set of alternative layouts. This approach involves the use of several layout design algorithms to generate candidate layouts that then being used as input to the analytic hierarchy process (AHP) so that multiple performance measures can be explicitly considered by the designer in selecting a 'best' layout. The analytic hierarchy process, allows the designer to express his tradeoffs between various pairs of criteria in selecting a best layout.
7	A Group Decision Model for Selecting Facility Layout Alternatives. *(Shui , Wen et al. 2005)*	Identify the attributes and criteria process in making the decision making. Introduced the Nemawashi Method as a group decision making method within their model.	Multi attribute and multi criteria have been identifying in this study. These multi attribute and multi criteria were used in the evaluation and selection process of layout alternatives done by the selected group decision maker. Nemawashi method has been used as a group decision making method within their model.
8	Group Decision Making Model: Facing a Facility Layout Selection Problem in Manufacturing Organization. *(Roslin et al. 2009)*	A review paper of the decision making method for solving the facility layout selection problems	The review paper suggested that the Group Decision Making method is the best solution for the selection problems in facility layout design.

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9	Optimal solution for the two-dimensional facility layout problem using a branch-and-bound algorithm *(Solimanpur and Jafari 2008)*	This research developed a mixed-integer nonlinear mathematical programming model for determining the optimum layout of machines in a two-dimensional area to minimize the total distance traveled by the material in the shop floor. An algorithm based on branch-and-bound approach is proposed to solve the linear mixed-integer models.	A new nonlinear mixed-integer programming model is presented for the facility layout problem in a two-dimensional area to minimize the total distance traveled by the material in the shop floor.. An algorithm based on branch-and-bound approach is developed to optimally solve the proposed mathematical programming model. Model The proposed model can also be applied to determine the processing route of products in an existing layout..

IV. DISCUSSION

As mentioned earlier, one of the major focuses in the facility layout problems is selecting the layout design. It is important in order to create an optimum layout at the least cost. However this problem is tackled separately by researchers. The fuzzy theory is the most applied method used. [3], [13] and [11]. "Reference [13]" used multi-attribute decision making (MADM) approaches in solving a layout design problem. In this study, two methods, the TOPSIS and fuzzy TOPSIS has been proposed and these methods are used in evaluating the alternatives layout designs by considering qualitative and quantitative design criteria. These methods were also used to evaluate a large number of layout design alternatives in order to reduce the risk of missing a high quality solution. The optimal solution cannot be achieved due to the MADM nature-need systematic evaluation in order to get the best solution. The model is only applicable to the specific application. Further studies on the MADM method need to be conducted in order to achieve the flexibility in finding the solution towards the facility layout selection problems. Besides [13], [11] have defined that the manufacturing facility layout problem is an unstructured decision making problem due to the vagueness associated with the inputs to the decision making models. As a result, they presented their work by simply demonstrating the potential applicability of the fuzzy set theory and offer a systematic guidance to the decision makers in making a decision on planning the facilities layout under the fuzzy theory concept. This concept of decision making application is based on material handling equipment selection routine under facility layout planning.

Meanwhile, besides the fuzzy theory concept, there are a few other concepts that have been used by researchers, such as Analytic Hierarchy Procedure (AHP) methods [16], Expert System [14], Group Decision making model [4], and also mathematical programming models [15], [17] and [18]. "Reference [16]", used Analytic Hierarchy Procedure (AHP) methods in finding the design criteria, this is used to generate the design alternatives by using the computer software application. These design alternatives will then be evaluated. The limitation of this study is that it depends on criterions that were chosen by the layout designer. Mistakes made during the selection process will give a negative impact to the evaluation process of choosing the best layout design.

Besides AHP, Expert system has also been used in determining the type of layout design. "Ref [14]" in his study introduced the expert system by using 5 fundamentals steps in order to find the criteria in generating an alternate path in facility layout planning. For future studies, the system has the capability to learn new process knowledge, suggest non-inferior solutions based on the multiple objectives considered or suggest good alternatives for a single objective. [14]

Group Decision making model had been used by [4] in their study. "Reference [4]" in their study was able to identify attributes and criteria process when making the decisions. These multi attribute and multi criteria were used in the evaluation and selection process of layout alternatives done by the selected group of decision makers. Furthermore, [4] introduced the Nemawashi method as a group decision making method within their model. However, when deciding on complex decisions, a more effective method is needed according to [4], the group of decision makers', needed to make decisions is large; around 60 – 80 peoples [20]. It is found that although all attributes and criteria were identified, a manual method was still required in the process to achieve a unanimous decision. "Reference [4]" claims that the Nemawashi approach can be profitable but further studies on more effective methods that is less time consuming needs to be done. Despite the facts, these studies are the starting point towards research into the fields of facility layout problems; focusing on selection methods in the facility layout alternatives. This will eventually lead into forming the best facility layout to the manufacturing organization.

Studies by using a mathematical programming model also were done by researchers. "Ref [15], [17] and [18] had used this method in their research on layout selection. "Reference [15]" in his studies had developed an integration model in optimizing the layout design. The model integrates the solution for production selection, capacity planning, process planning and the facility layout. This model will help the manufacture to make a wise decision starting from the initial stage of the manufacturing process. Regrettably, this can only be applied to new established manufacturing organizations and also to those manufacturing organization that have a variety of production outputs.

"Ref [17]" on the other hand has introduced a decision support system known as LayoutManager. LayoutManager functioned as a tool for the planner in layout design process. The system provides the tools to create layout plans, generate alternative plans and to assess alternative plans with respect to productivity criteria of the choice. The system allows the planner to create block plans automatically, minimize the total distance travelled, and to improve existing plans. The limitation of this study is the system can only measure the production cost based on the manpower allocated in each process. This limited

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cost benefit analysis does not give enough information such as on cost of materials and its operational cost for the decision maker in making their selection.

Besides [15] and [17], [18] also made a study based on the mathematical programming. “Reference [18]” proposed the mixed-integer nonlinear mathematical programming model for determining the optimum layout of machines arrangement in a two dimensional area. The study focuses in minimizing the total distance travelled by material in the shop floor. The limitation of this model is that it cannot be used for large size combinatorial optimization problems which need to be solved within a reasonable time.

V. Future Study on the Facility Layout Design Selection

Most researchers concentrate on the problem of facility layout design. Based on the review, the study on optimizing the layout design had been done although achieving the optimal layout is not easy as it seems. However studies focusing on the problems in selecting the layout design are limited. Selection or the process of making decisions to produce the perfect layout for an organization depends on how the decision is arrived at.

Available studies have become the base or hurdle for future research in order to solve this problem. They are to ensure that the results in selecting the layout design are the best /right one based on the review of available literature.

The author’s ultimate goal is to develop an integrated model on selecting the layout design by using the expert system and group decision making method focusing on the model that can be best used in optimizing and selecting the layout design. The model should be able to give suggestion on the best layout design, not only focusing on the machine arrangement but also provide suggestion on cost – benefit analysis – production and operational cost of the layout; plus the most important factor which is the time saving approach. The aim of this study is to develop a comprehensive model that would provide a useful tools in optimizing and making selection of the layout design.

VI. Conclusion

This paper reviewed previous studies done in solving the layout design selection problems within the manufacturing organization; it is one of the major focuses in the facility layout problems. Although studies on the selection of the layout design are limited, it could become the base for future research direction. An integrated model on selecting the layout design has been proposed by the author. This model will integrate two important processes in layout designing which are optimizing cost and selecting the best layout design. This model integrates its own characteristics which is the cost benefit analysis and time saving approach.

Dependability on data and outcomes of other studies done could be counterproductive, simply because layout designs are usually exclusive in-nature to a specific design plan. Albeit, available information can be used as reference, an innovative interpretation, parallel analysis and adaptation feasibility study needs to be undertaken by planners. Then only a decision could be derive on the best possible model to be applied within the needs of the manufacturing organization. This ensures that there is continuity of knowledge enhancement within this field.

References

[1] Tompkins, J.A., White J.A., Bozer, Y.A. Frazelle, E.H., Tanchoco, J.M.A and Trevino, J. (1996). Facilities Planning, Wiley, New York.

[2] Drira, A., H. Pierreval, and S. Hajri-Gabouj, Facility layout problems: A survey. Annual Reviews in Control, 2007. **31**(2): p. 255-267.

[3] Roslin. N.H, Seang.O.G, Dawal.S.Z. , 2009, Group Decision Making Model: Facing a Facility Layout Selection Problem in Manufacturing Organization. Proceeding of the International Conference for Technical Postgraduates 2009 Conference. TECHPOS 2009.

[4] Shui S.L., Wen C.C, Ron H.L, Chyung P. and Jen T.T. (2005). A Group Decision Model for Selecting Facility Layout Alternatives. IEMS Journal, 4, No. 1, 82-93.

[5] Heragu S.S. and Kusiak A. (1990). Machine Layout: An Optimization and Knowledge Based Approach. International Journal of Production Research, 28, (4), 615-635.

[6] Heragu S. (1997). Facilities Design, PWS Publishing Company, Bostan.

[7] Yaman R., Balibek E. (1999). Decision Making for Facility Layout Problem Solutions Computers & Industrial Engineering, 37,319-322.

[8] Francis R.L. and White J.A. (1974). Facilities Layout and Location: An Analytical Approach, Prentice Hall, Englewood Clifs, NJ.

[9] R. C. Lee & J. M. Moore. (1967). CORELAP-Computerized Relationship Layout Planning. Industrial Engineering, 18, 195-200.

[10] T. Yang, C.A. Kuo. (2003). A hierarchical AHP/DEA Methodology for the Facilities Layout Design Problem. European Journal of Operational Research, 147,128–136.

[11] Deb ,S.K. ,Bhattacharrya, B. (2005). Fuzzy Decision Support System for Manufacturing Facilities Layout Planning. Decision Support Systems, 40, 305-314.

[12] McLean, C. Kibira, D. Virtual Reality Simulation of a Mechanical Assembly Production Line. Proceeding of the 2002 Winter Simulation Conference. Page 1130-1137.

[13] Yang, T. and C.-C. Hung (2007). "Multiple-attribute decision makingMethods for plant layout design problem." Robotics and Computer-Integrated Manufacturing 23(1): 126-137.

[14] Kumara, S. R. T., R. L. Kashyap, et al. (1987). "Expert System for industrial facilities layout planning and analysis." Computers & industrial Engineering 12(2): 143-152.

[15] Askin, R. G. (1986). "A formulation of the integrated facility layout, product selection and process planning problem." Journal of Manufacturing Systems 5(4): 267-269.

[16] K.E. Cambron, G.W. Evans. (1991). Layout Design Using the Analytic Hierarchy Process, Computers and Industrial Engineering, 20 (2), 211–229.

[17] Foulds, L. R. (1997). "LayoutManager: A microcomputer-based decision support system for facilities layout." Decision Support Systems 20(3): 199-213.

[18] Solimanpur, M. and A. Jafari (2008). "Optimal solution for the two-dimensional facility layout problem using a branch-and-bound algorithm." Computers & Industrial Engineering 55(3): 606-619.

[19] Heragu, S. S. and A. Kusiak (1991). "Efficient models for the facility layout problem." European Journal of Operational Research 53(1): 1-13.

[20] Ouchi reference. Cited in Watabe, K., Holsapple, C. W. and Whinston, A. B. (1992). Coordinator Support in a Nemawashi Decision Process. Decision Support Systems, 8, 85-98.

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