Analysis and Simulation-Based Optimization for solving facility layout problems: A Literature review

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Abstract– Facility layout planning (FLP) entails a collection of design issues including the placement of elements that define industrial production systems in a physical area. Because they are one of the most essential design considerations in company operation strategies, and because of their demonstrated impact on production system operating costs, efficiency, and productivity, this topic has received a lot of attention in science. In this light, the current paper presents a scientific literature review on FLP from the standpoint of Simulation-Based Optimization. By setting the material handling system and techniques to produce and analyze layout options, the examined papers were categorized as a wide taxonomy based on the kind of problem, strategy, planning stage, and features of production facilities. We emphasis that while mathematical optimization models were primarily used to produce layout options, other techniques such as expert knowledge and specialist software packages were also used. In general, the most often used solution algorithms.

Key words: layout of facility, optimum facility layout, simulation

I. INTRODUCTION

Facility layout planning refers to the act of physically arranging all of the production variables that form the production system so that it can sufficiently and efficiently comply with the organization's strategic objectives (FLP). One of the most important design decisions in business operational strategy is FLP. It also has a significant impact on industrial system efficiency and productivity [1]. Efficient FLP must ensure that production schedules are met in the short, medium, and long term, and at a lower cost, while also making proper use of space, allowing for future re-layouts, and minimizing health/security concerns at work. Inefficient design, on the other side, can lead to bottlenecks, congestion, and unused space, as well as too much work accruing and job positions becoming idle or congested. All of this can contribute to worker anxiety and discomfort, workplace accidents, and challenging operational and people management control. Furthermore, if there is a lack of closeness among the organization's working centers, the working day in transportation activities cannot be maximized, which adds no value. This is one of the primary reasons that manufacturing times lengthen and work productivity levels fall [2]. Despite its importance, FLP is a tough subject to address. The most efficient development and selection of facility layouts for an organization requires a complicated and iterative process based on grading the aspects that create the goods/services production system. According to computational complexity theory, FLP is an NP-hard (non-polynomial hard issue) optimization problem since no solution methods exist that provide an optimum solution in a tolerable polynomial time [3]. Despite their complexities, a number of authors have solved these challenges by providing acceptable answers in realistic calculation times. The problem is classified as static or single-period FLP when it is planned with the assumption that demand would remain constant throughout the planning horizon (SFLP). However, in many manufacturing processes, evaluating a single design may be impossible because material flow is unlikely to remain consistent throughout time. When demand is seasonal or varies significantly, it may be more advantageous to use a separate FLP for each time period, in which case the planning technique is either dynamic or multiperiod (DFLP) [4]. Factory layout is a method of organizing a factory's physical spaces to facilitate a productive operation) [4] [1]. Facility layout is a function that comprises the analysis (synthesis), planning, and design of the relationships between physical facility arrangements, material movements, personnel activities, and the flow of information in order to achieve peak performance in a variety of linked activities [1] [2].

2. OVERVIEW OF SOLUTION METHODS

Several specific optimization strategies have been created and applied over the past decades to address the various forms of FLPs. The most commonly used optimization methods include simulated annealing (SA), genetic algorithms (GA), tabu search (TS), ant colony optimization (ACO), and particle swarm optimization ((PSO). Furthermore, hybrid heuristics and metaheuristics that incorporate some of these approaches show promising results and offer promise for solving complex FLPs in the future.

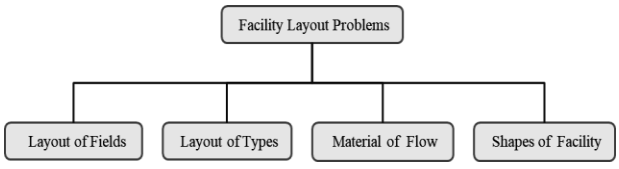

Fig. 1

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depicts the FLPs solution approaches. When an issue is modest or simple to solve (number of departments, n 30), it is best to utilize accurate approaches that guarantee an optimal solution.To solve unequal FLPs, a few methods are often employed, such as pair-wise exchange (Fortenberry and Cox, 1985), graph theoretic approaches [15]. and branch and bound [17]. Fig. 1 provides an overview of works in which various approaches have been used to solve FLPs. The scope of this study does not allow for detailed investigation on the application of the particular approaches.

Fig. 1: Facility Layout Problems.

3. SIMULATION TECHNIQUE

The facility planning analysis also suggests using simulation techniques. According to Nica, et al. [18], Uncertain arrival timings characterize the phenomena of components queuing up before approaching an assembly location. In this stochastic condition, simulation is a useful tool to assist the designer in defining the storage spaces of the assembly system. In this study, a concept known as an ordered parts buffer is developed for using robot systems to sequence components as they enter the assembly process. Ekren and Ornek [19] created a simulation based on experimental design for the conventional industrial job-shop setup. They looked at how different layout types affected the system's performance and how they interacted with other production factors. As an analytical tool for line reconfiguration to account for future demand variation, a simulation model has been developed. The research's primary problem is line balancing, and a fuzzy knowledge base method was suggested to assist construct more plausible scenarios [20]. A sophisticated assembly system's requirement for sequence coordination is presented. This is because complicated assembly systems often involve a preassembly portion for part preparation, and this information can only be obtained through computer-aided simulation. Arena [21], QUEST [22], IGRIP [23], Pro Model [24], and Witness [25] are simulation programs that are often used in facility planning. Flexsim is an additional tool for layout simulation. It is for discrete event simulations is used to assess, plan, or develop manufacturing, logistics, and other operational and strategic scenarios [26]. Many software programs only offer two-dimensional (2D) visualization, which is difficult to visualize, comprehend, and assess. The three-dimensional (3D) visualization is provided by Flexsim. Software called Flexsim enables researchers to quickly evaluate a number of possibilities without taking any risks or incurring any costs. Shown table 1 the summary of research in this field.

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SL.No	Title and Author	Methodology
1	A case study of a low-capacity production line layout design Flippo De Carlo et.al[10]	Empirical
2	A heuristic method is used to tackle the integrated facility layout design and flow assignment problem. Ali Taghavi et.al[02]	A novel integrated heuristic method was proposed, which is based on a perturbation algorithm and a sequential location heuristic.
3	a genetic algorithm paired with a heuristic strategy to address the issue of multi-line layout Amir Sadrzadeh[03]	The study proposes a meta heuristic for FLP that is based on a Genetic Algorithm.
4	A Case Study of Simulation Used in Facility Design (Greasley, 2008)[13]	To determine the amount of storage space needed for a potential overseas textile production plant, a discrete event simulation model was created.
5	A strategy for resolving the issue of uneven facility layout utilising measurements based on distance and form R. Logendran et.al[26]	It is developed a mixed binary nonlinear programming model.
6	An alternate approach of multiple attribute decision making for choosing the best facility plan design K.D.Maniya et.al [20]	Preference selection index is the foundation of the suggested technique (PSI)
7	Tabu Search, Simulated Annealing, and Genetic Algorithms for Facility Location Problems: An Empirical Comparison (Arostegui *et al*, 2006)[5]	On several facility location problems, compare the relative effectiveness of Tabu Search (TS), Simulated Annealing (SA), and Genetic Algorithms (GA) (FLP).
8	Genetic Algorithms for Integrating Cell Formation with Machine Layout and Scheduling. (Xiaodan et al, 2007)34	A novel strategy for jointly deciding on cell formation (CF), group layout (GL), and group scheduling (GS) for effective cellular manufacturing was proposed (CM). It is suggested to use a conceptual framework and mathematical model that incorporates these choices.

4. RESEARCH TRENDS

In addition to in this literature survey, the key tools for designing and solving facility layout problems include heuristic, meta-heuristic, and planning, simulation technology, safety consideration, flexible manufacturing systems (FMS), and Lean Manufacturing Systems (LMS) drivers. The previous century's literature shows little interest in hybrid strategies for MCDM, which are now quickly emerging.

5. GAPS AND DIFFICULTIES

Despite the relevance of simulation and optimization drivers in facility layout design, as previously stated, we discovered numerous types of study that did not contain these drivers. MCDM, hybrid MCDM, and fuzzy MCDM have all been discussed in the past. Another gap in the literature was the use of an incorrect algorithm; some authors combined

6. DISCUSSION

According to the aforementioned literature study, several studies have evaluated the efficient design of facility planning in a manufacturing process's production line. However, employing generic heuristic techniques to identify the optimal layout configuration, such as Tabu Search (TS), Simulated Annealing (SA), and Genetic Algorithms, has various downsides and limitations (GA). Time constraints and the inability to see the exact placement and size of the machinery and equipment in the facility design are among the restraints. The simulation approach is an important tool for testing and evaluating potential configurations in layout optimization. According to Mc Lean and Kibira [24], computer simulation

holds enormous promise for future productivity, product quality, lead time reduction, and cost reduction.

Simulation may be the most effective decision-making tool for industrial system design, analysis, and improvement.

Arena, Witness, and Pro model are two-dimensional (2D) simulation programs used by some researchers. A 2D perspective arrangement, on the other hand, could not reveal the exact setting and proportions of the machine and equipment. Discrete event simulation software has expanded rapidly in recent years. One of them is Flexsim software. The design may be seen in three dimensions (3D). Designers can use this program to construct virtual reality (VR) environments and feel the ambience of a factory. Potential issues such as safety concerns, aisle and other layout obstacles can be visualized and changed by employing plant layout problem solving approaches. In the future research of some literatures, there are a few new approaches of facility design analysis. One of them is evaluating the existing layout arrangement by combining 3D simulation and core heuristic methodologies. The purpose is to do a more in-depth analysis to determine the best layout configuration.

7. CONCLUSIONS AND FURTHER RESEARCH

It is vital to optimize plant layout for new units or re-layout existing manufacturing units in accordance with changing market scenarios in order to maximize returns from facility capacity. Several researchers have developed several models using heuristic and meta-heuristic approaches while considering various case studies. In optimization, heuristic approaches such as Tabu Search (TS), Simulated Annealing (SA), and Genetic Algorithms are often utilized (GA).

The downsides of these heuristic approaches include their time-consuming nature and inability to accurately depict the actual surroundings and size of the machine and equipment.

Aside from heuristic tactics, simulation methodology is a powerful tool that many academics employ before implementing a recommended layout design. When assessing the shortcomings of the methods presented thus far, a combination of heuristic approaches and simulation techniques can be used to create a method that is more effective and complete. The use of MCDM to design multi-objective optimization algorithms and validate them with practical simulation is also illustrated.

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