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A Research on Dynamic Facility Layout Problems

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Abstract*: *Among the several features of the manufacturing system, the facility layout problem (FLP) is a one of the significant issues. An endeavour is made in this paper to show the best review on Dynamic Facility Layout Problems (DFLPs). Here, a writing survey is made by referring to various papers on DFLPs. This paper aims to discuss present and future trends in DFLP research based on past research data such as layout evolution, characteristics of the workshop, problem formulation and Resolution approaches.

Key Words: Facility layout; Dynamic layout; Optimization methods; Manufacturing facility.

I. INTRODUCTION

Facility layout planning acts a major role in the process of manufacturing and seriously affects the benefit of an organisation. An effective layout of the facility lessens the manufacturing lead time and will in general increase the throughput, consequently expanding the overall productivity and efficiency of the facility.

Since the mid-1950s, research on the FLP has formally started. [1] Specifically, introduce a tree diagram of the different variables is to be considered when dealing with an FLP[2]. The paper is composed in section 2 describes La yout development and its classification in section 3 overviews the workshop characteristics in section 4 explains the problem formulation, objectives and constraints in section 5 discusses about the resolution approaches. Finally, the last section ends with the conclusion and possible directions for future research.

II. LAYOUT EVOLUTION

The FLP can be categorized further two subcategories: Static Facility Layout Problems (SFLP) and Dynamic Facility Layout Problems (DFLP). The layout design for the multi - period is fixed in a static design and there is no re-arr angement cost. The drawback of static layout is that it can't deal with varieties in products and their demands. To overcome the issues connected with static facility layout, dynamic layouts are designed. A few endeavours have been made to address DFLP. In a dynamic layout, MHC and re-arrangement cost for the multi-period is minimized and the layout design of each period is given.

III. FACILITY / WORKSHOP CHARACTERISTICS

According to [1, 2] classification of the layout problems was represented in a Tree structure. The workshop characteristic includes the facility shape and dimension, manufacturing systems, material handling and flow movement are discussed below.

3.1 Facility Shapes and Dimension

Based on the reference in the literature, facilities are two types: regular and irregular shapes. A fixed length and width can be utilized to characterize a facility. [3] Considering a construction project problem with regular and irregular shapes including aspect ratio. In the investigated DFLPs, some of the studies concern aspect ratio most of the studies consider regular shapes with fixed measurements.

3.2 Manufacturing Systems

Manufacturing systems may be subdivided into four categ ories: product, process, fixed position and cellular layout. Product or straight-line layouts are used for highly standardized and high-volume products. In process layout, similar functions or process are grouped together and named as departments, it is used for standardized and low volume products. In fixed type, the major item should be fixed in one location, where machines, equipment, labor, and other components are moved. The primary item delivered is fixed in a fixed position design in single area and all segments, equipment's, machines and laborers are provided to the area.

Cell layout has many benefits compared to the product an d process layout, for example reduced MHC, lead time, waste, work-in-process inventory, hazards and improves productivity and quality. In recent works on cellular layout problems for DFLP. [4, 5, 6, 7].

3.3 Material Handling System

It assumes a significant job in manufacturing. Determination and suitable course of action of dealing with gadget over a way to diminish material taking care of expense (MHC). The review [9] covers in detail three classifications of layout problems, which incorporate line, unequal-areas and multi-floor layout. Based on two perspectives MHS can be assessed as following:

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(i)Equipment for material taking care of, for example, AGVs, robots, transports (wheels, rollers, belts, etc.

(ii) Layout design: The format is delegated single, twofold, multi-lines, parallel-push, circle, open-field and multi-floor format dependent on the sort of material dealing with course of action.

3.4 Flow Movement

The two flow movements related to layouts that impact the product flow. The following indications are Backtracking and Bypassing are shown in below (figure 2).

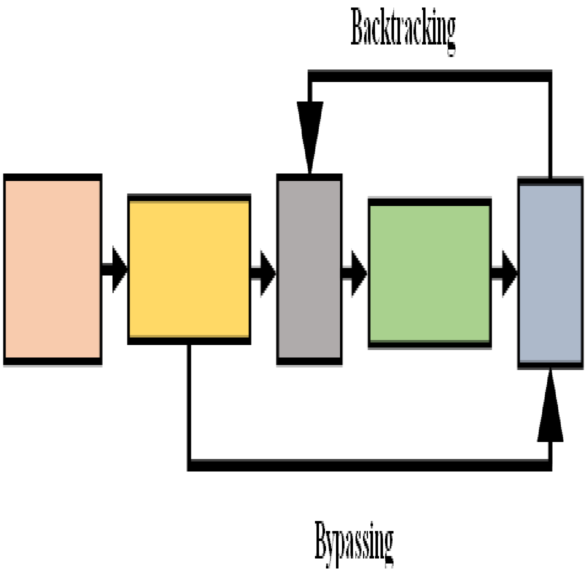

Fig. 1: Backtracking and Bypassing

Backtracking implies moving of a product from one way to another way in a backward order of the facilities in flow movement. Bypassing implies where a product disappears from certain facilities while moving towards the stream development.

IV. PROBLEM FORMULATION

Various sorts of mathematical models can be utilized to plan format issues and to express the unpredictable connections among the various elements in a FLP. It is formulated into two different varieties: discrete and continuous formulation as shown in below (figure 3).

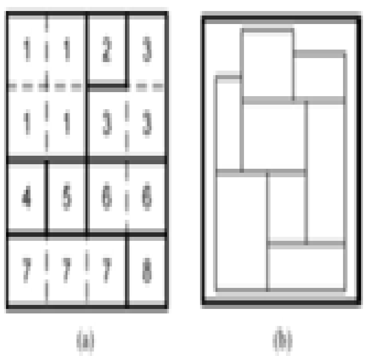

Fig. 2: Discrete and Continual Layout Representation

The problem would be limited in discrete formulation, yet unpredictable shapes can be worked here on the other hand only regular shapes can be accomplished in consistent definition. The dynamic condition QAP is still more intricate than static QAP due to an introduction of periods in the dynamic QAP. [10] DFLP is works based on QAP with unequal regions and multi-objectives for minimizing MHC and rearrangement cost. Pourvaziri and Pierreval [11] included work-in-process in DFLP.

Moslemipour et al. [12] discussed some DFLP studies formulated for unequal size facilities with continuous representations by MIP. Jolai et al. [13] developed problem by MIP considering a multi-objective DFLP. DFLPs can be formulated as a GT model problem, consisting of various vertices (nodes) and edges. The facilities are represented by vertices (nodes) in the graph. Dong et al. [14] formulated DFLP using nodes and flow chart arcs using GT models.

The DFLP was formulated by Kaveh et al. [15] considered fuzzy numbers to make a model product market demand uncertainties. Xu et al. [16] utilized fuzzy numbers logic for representing the closeness relationship among temporary facilities. Bozorgi et al. [17] applied data envelopment analysis (DEA) taking into account of particular criteria's like costs, adjacency, and requested distance.

a. Objective function

Normally, there are usually two kinds of objectives for FLP. Quantitative objective target to minimization of overall MHC between departments based on traffic congestion, distance function, rearrangement cost, shape irregularities etc. Qualitative (adjacency-based) objective which maximizes the closeness ratio between the placement of departments.

Most authors use the methods of Analytic Hierarchy Process (AHP) as a procedure or a linear merge of the various objectives into a single one. Based on minimization and maximization objectives the common multi objectives adopted in the recent DFLPs were tabulated below in Table 5. A few researchers included alternate specific objectives alike hazardous score, layout flexibility, space restriction, and so on. Tayal and Singh [18] considered hazardous score depend on the type of product, facilities safety guidelines and working environmental conditions for reducing the risk of hazard.

Table 1: Minimization And Maximization Objectives

Type	Objectives
Minimization	Minimization of material handling and adjustment costs Minimization of travel time, shape proportion, traffic distance, work in process, construction cost, nearness and separation demand, distance restriction, flow distance and waste, machine rearrangement cost, total shifting costs and transportation, penalty value (department together), machine and operator related costs, unsuitability between departments and locations Minimization of unfilled and full outings of the MHS Minimization of the representative score of safety/environment concerns Minimization of machine relocation and inter/intra cell movements of parts Minimization of total costs by idle or obsolete (MHDs) Minimization of total cost of material flows (distances) between facility locations
Maximization	Maximize profit, efficiency, satisfaction, adjacency rate, hazardous score, distance request Maximize closeness rating value, closeness relationship score Maximize accessibility and maintenance Maximizes consecutive forward flows ratio Maximize shape ratio and flexibility Maximize adjacency score and cost

b. Constraints

Amine Drira et al. [1] represented constraints in designing facility layout are: space constraints (area and facilities allocation), positioning (orientation, clearance among facilities, pick-up/drop-of points and non-overlapping) and budget constraints. Kia et al., [5,7] proposed capacity constraint generally refers to the machine capacity limitations. The mathematical model for resolving the two objective DFLPs with budget constraints was developed by Manoochehri and Mohammadjafari [19].

V. RESOLUTION APPROACHES

As per previous literature resolution approaches for DFLP are: exact methods, heuristics, metaheuristics and hybrid approaches.

a. Exact Methods

Exact methods classified into three types Dynamic programming (DP), Branch and Bound (BB) and modified sub-gradient (MSG). Generally, DFLP is NP-hard type problem for this type of problems the exact (optimal) methods are used for small-sized problems.

While an optimal dynamic programming solution method is available, it is not feasible for large DPLPs. Branch and bound algorithm were utilized to attain a viable way for solving problems along NP-hard optimizations. A small multi-period distribution problem based on branch and bound procedure has been resolved by Lahmar and benjaafar [20]. For resolving the continuous non-linear model, the Modified sub-gradient algorithm was used.

b. Heuristic algorithms

For solving the large-sized DFLPs heuristic algorithms are used for finding optimal solutions. It is also known as sub-optimal approaches. Balakrishnan et al. [21] suggested an improved dynamic pair-wise exchange heuristic on the basis of an earlier Urban's technique.

In this, the two improvements were backward method used for pair-wise exchange heuristic and combined urbans heuristic with dynamic programming. As an improvement to the urbans technique to create pareto-optimal layouts Ripon et al. [22] suggested a backward pass heuristic method for multi-objective DFLP under uncertainty.

c. Metaheuristics

Usually heuristics are problem-dependent while meta-heuristics are problem-independent techniques that can be adopted to resolve broad problems. Some of the metaheuristic approaches applied for DFLP are discussed below. Simulated Annealing (SA) algorithm is a sequential search algorithm. It is simple to implement unlike other meta-heuristics and widely used for solving complex engineering problems. Baykasoglu and Gindy [24] used an upper and a lower bound of a solution for determining the SA parameters by implementing SA heuristic.

Kulturel-Konak et al. [25] proposed TS heuristic for bi-objective model minimizing MHC and re-layout cost for unequal area redesign facility relayout problem. For obtaining required efficient layout Bozorgi et al. [17] applied TS heuristic using a diversification strategy that combines penalty function, frequency-based memory and dynamic tabu list size to the DEA model. Three TS heuristics for DFLP resolution were proposed by McKendall and Liu [26] simple TS heuristic; combination of TS heuristic with diversification and intensification strategies and last one is a probabilistic TS heuristic.

Genetic algorithm is very powerful for searching larger regions of the solution space globally. To resolve a problem of multi floor dynamic cellular layout a matrix-based chromosome GA was developed by Kia et al. [7]. For solving large sized DFLPs Balakrishnan and Cheng [21] proposed a GA with nested loops. Ripon [22] presented a hybrid GA with including jumping genes and a modified backward pass pair-wise exchange heuristic to evaluate its effectiveness to optimize MHC while solving the DFLP. By using modified Backtracking Search Algorithms (mBSAs), the classic Backtracking Search Algorithm (BSA) and GA Vitayasak et al. [27] solved a Stochastic DFLP.

To resolve the DLP in consideration of budget constraint Baykasoglu et al. [28] proposed the ant colony optimization algorithm (ACO). In order to resolve single objective optimization (SOO) and multi- objective optimization (MOO) problems for dynamic construction site layout problems Ning et al. [3] proposed two mathematically optimized models max–min ant system (MMAS) and modified Pareto-based ant colony optimization (ACO).

For solving multi-objective DFLP Emami and Nookabadi [29] considered useful tools are population-based metaheuristics such as non-dominated sorting genetic algorithm (NSGA-II), a Pareto-simulated annealing (PSA) and differential evolution (DE). In order to solve the SFLP and DFLP with unequal area Derakhshan and Wong [30] proposed a modified PSO.

Jiying et al. [31] used an artificial bee colony algorithm (ABC) for resolving a mathematical model to find the feasible solution considering human factors like safety, rich efficiency, low price and sustainability with penalty function. Ghosh et al. [32] developed a soft computing technique by using improved GA and a SA heuristic (SAH) to solve dynamic multi-objective layout problems. Turanoglu and Akkaya [33] proposed fuzzy decision support system by integrating multiple input types for determining the closeness rates between the departments in the DFLP. Xiao et al. [34] intoduced a mixed linear integer programming (MILP) for DFLP with a new combination of computational experiments problem evolution algorithm (PEA) and linear programming called PEA-LP.

d. Hybrid algorithms

The combination two or more algorithms for finding the effective solutions are known as the hybrid algorithms. Gary et al. [35] proposed encoding and decoding schemes for large DFLPs using hybrid ACO with a new data solution structure. Pourvaziri and Naderi [36] proposed an adequate novel hybrid multi-population GA for DFLP resolution.

Dileep et al. [37] suggested new methodology for finding the solution to the DFLP with budget constraint by developing a hybrid multi population genetic simulated annealing algorithm (MPGSAA). To designing a proper DFLP with transportation design for specific planning horizon Hasani et al.[38] proposed an effective hybrid meta-heuristic related on variable neighborhood search (VNS) and simulated annealing (SA).

In order to identify the almost optimum solutions by coding and decoding technique, Hosseini et al. [39] introduced a hybrid particle swarm optimisation (HPSO) algorithm allowing the align of a resolution in discrete space of DFLP to PSO particle position in continuous space. Parham azimi et al. [40] presented a hybrid heuristic procedure by combining the discrete PSO algorithm and simulation technique to solve DFLP. Hosseini et al. [41] incorporated 3 meta-heuristics: imperialist competitive algorithms (ICA), variable neighbourhood search, and SA to form a hybrid technique to solve the DFLP.

Uddin [42] suggested a noval hybrid meta-heuristic GA-VNS for DFLP where the population was divided into two parts as GA and VNS for better solutions. Liu et al. [43] proposed Wang-landau (WL) sampling algorithm for DFLP. Moslemipour [44] proposed a new hybrid intelligent algorithm by including clonal selection (CS) and simulated annealing (SA) to resolve uncertain DFLP. The optimal layout for garment manufacturing unit is provided by combining hybrid Firefly Algorithm (FA) and Chaotic Simulated Annealing (CSA).

Moslemipour et al. [45] introduced a new hybrid algorithm AC-CS-SA including new QAP depend on mathematical model to design a robust layout for solving DFLP. Tayal [46] was applied SA-DEA-TOPSIS to identify a subset of efficient layouts. In addition to heuristic methods, simulation method is a powerful tool used by various researchers in creating and evaluating the proposed layout design before implementation. Simulation software tools generally applied in facility layout design are QUEST, Witness, IGRIP, Pro-Model and Arena [47].

VI. DISCUSSION

On the Basis of above writing study, it is revealed that there are a few examinations researched the viable structure of office arranging in a generation line of assembling process. Nonetheless, there are a few troubles and impediments in finding ideal format design with the general heuristic techniques, for example, Simulated Annealing (SA), Tabu Search (TS) and Genetic Algorithms (GA). The constraints are, for example, tedious and can't get vibeof the real setting and genuine element of the machine and gear in the office plan. Simulation strategy is a useful asset for evaluating and assesses the conceivable setup in format improvement [48]. There are likewise new systems for analysing facilities design later on researching certain literary works. In assessing the current course of action of the design, one of them joins the fundamental techniques in 3D simulation process. The goal is to break down the ideal design course of action progressively.

VII. CONCLUSION

In this paper, conferred a comprehensive analysis associated to DFLP's. It gives an overview to the researchers for identifying the possible work area and suitable factors to be selected in the work area of DFLP. The literature survey shows that multiple factors affect the plant layout and this must be considered a problem of multi objective optimization. The most research papers focus on manufacturing system applications, there is a need to consider the special objectives and some constraints like adding or removing machines in different periods, flexibility in routing and also need to implement the advanced solution methodologies by combining different approaches for the better improvements in the DFLP research area.

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