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OPTIMISATION OF PLANT LAYOUT DESIGN USING CRAFT TECHNIQUE

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Abstract

Layout planning is nothing but deciding on the best physical arrangement of all resources that consume space within a facility. The arrangement of resources in a facility can significantly affect the productivity of a business. Layout planning has prime importance in industry. In this paper, a 3 X 3 unequal areas of machine layout considered [1]. Material handling cost of existing layout is calculated. To reduce the material handling cost the design layout is optimized using the computerized relative allocation of facilities technique (CRAFT).

Keywords:

Layout Planning;
CRAAFT;
Material handling cost;
Machine layout.

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1. INTRODUCTION:

Layout planning is performed any time there is an expansion in the facility or a space reduction. Layout planning. Deciding on the best physical arrangement of all resources that consume space within a facility. The arrangement of resources in a facility can significantly affect the productivity of a business. Layout planning is deciding on the best physical arrangement of all resources that consume space within a facility. These resources might include a desk, a work centre, a cabinet, a person, an entire office, or even a department. Decisions about the arrangement of resources in a business are not made only when a new facility is being designed; they are made any time there is a change in the arrangement of resources, such as a new worker being added, a machine being moved, or a change in procedure being implemented. Also, layout planning is performed any time there is an expansion in the facility or a space reduction**.**

2. LITERATURE:

Andrew kusiak and Sunderesh S. Heragu surveyed facility layout problem and presented various algorithms for facility layout problems and presented certain issues related to the layout problems. And they also proposed improvement algorithms such as CRAFT, H63, SAMPLING ANGORITHM, COL, FRAT, and REVISED HILLIER ALGORITHM.

Ardavannozari and E.EmoriEnscore, Jr. described plant layout procedure based on graph theory, given a relationship chart for the departments of layout, the branch and bound technique is used to obtained the planar representation diagram via a single planarity testing procedure. The planar's graph dual graph is found which

gives the topology of the proposed final layout. Using the topology of the dual graph, one can place the departments into final layout. Due to the time and complexities involved the entire layout procedure is computerized. A.S.Ramkumarand S.G.ponnambalam addressed a layout design of physical layout is one of the most important issues that must be solved in early stages of the F.M.S design. They also simulated annealing algorithm and genetic algorithm and the performance of the two algorithms for solving single row machine is evaluated.

E.Pesch et.al (1999) introduced new neighbourhood structures to generate an initial solution and yield feasible modifications of a given layout. G.H.Hu, et.al carried out the traditional optimization for the cell system layout (CSL) and material handling system in cellular manufacturing systems(CMS'S) sequentially and separately. An integrated approach to the problem is proposed that attempts to design C.S.L and flow path structure simultaneously. The cells in question are assumed to be shape fixed. Here genetic algorithm is used to solve the problem. J-Y. Kim and Y-D. Kim considered the unequal size facility problem with the objective of minimizing the total transportability on distance. This is obtained by using Graph theory and CRAFT.

K.Ravikumaet.al., described a constructive heuristic which provides solutions to the single row facility layout problem so as to minimize the material handling cost. L.R.Fouldsdid survey on work done to date on the problem of lay out the facilities of some system in terms of specifying which activities are to be a adjacent. Each pair of facilities has a closeness rating, which represents the desirability that they are located adjacently. They have to design a system so that the sum of the ratings of adjacent pairs is maximized as this represents the travel speed.

Pinto wilsten, J.Shayan.E took a layout problem at a furniture manufacturing company and developed that initial layout using various algorithms such as Graph theory, CRAFT, optimum sequence, Blocplan, Genetic algorithm. Randy allenbach and marywerner made the (CRAFT) program using the heuristic to determine the best relative location of areas and to obtain high level layout. Robin .S .Liggett reviews the history of automated facility layout and focusing particularly on a set of techniques which optimizes. S. P. Singh proposed an approximate algorithm is proposed to solve facility layout problem (FLP), which is formulated as quadratic assignment problem (QAP). They proposed an approach for linear assignment problem (LAP) which is solvable in polynomial time.

Taho yang, chuweikuo proposed a hierarchical analytic hierarchy process (A.H.P) and data envelopment analysis (DEA) approach to solve a plant layout design problem. CRAFT was originally presented in Armour and Buffa (1963) and Buffa et al. (1964). The principle involved in CRAFT is so popular that it has been modified frequently. Examples of such modifications are COFAD (Tompkins and Reed, 1976) biased sampling technique (Nugent et al., 1968), COL (Vollman et al., 1968), CRAFT-M (Hicks and Cowan, 1976), SPACECRAFT (Johnson, 1982) and CRAFT-3D (Cinar, 1975). SPACECRAFT (which was\ published later than CRAFT-3D) is very similar to CRAFT-3D (Jacobs, 1984). CRAFT begins by determining the cost of the initial layout. It then evaluates all possible location exchanges between pairs of facilities which either are adjacent to each other or are of the same area. The location exchange which results in the greatest estimated cost reduction, is made. This procedure continues until there is no location exchange which results in a lesser cost than that of the current layout. CRAFT can handle only forty facilities and does not perform well when the facilities are of unequal areas (Foulds, 1983, Scriabin and Vergin, 1976).

3. FACILITY LAYOUT PLANNING:

Layout planning has prime importance in industry. In this paper, a 3 X 3 unequal areas of machine layout have been considered [1]. Material handling cost of existing layout is calculated. Initial layout is constructed by A heuristic algorithm(W.M. Chan, C.Y. Chan*,). To construct the initial layout the number planning periods are considered are nine, types of parts are 5 and number of machines are 9. Table 1 shows the sequence of required machines to produce the five parts. Table.2 shows the demand of each part in different planning periods.

Table 1: Represents the required machines and their sequences to produce the five parts

Type of parts	Operations sequence of parts
1	1→3→5→7→2→7→9
2	1→4→2→5→6→8→9

3	1→5→7→8→5→6→2→9
4	1→2→4→6→7→8→2→3→9
5	1→7→6→4→2→8→3→5→6→9

Table.2 Represents the quantitative demand of each type of part in the five planning periods.

Type of part	Period1	Period2	Period3	Period4	Period5
1	10	35	90	40	55
2	30	50	25	65	20
3	45	15	40	70	15
4	70	80	55	90	85
5	85	60	70	20	30

3.1 Steps involved in the construction of initial layout design using

Following are the steps involved in the preparation of initial layout. Fig.1 shows the initial layout design for the period 1, similarly the procedure is continued for the reaming periods.

a. Calculate part transportation frequencies.
b. Calculate part flow weight matrix.
c. Merge part flow weight matrix.
d. Rank the part flow weight matrix.
e. New machine cluster generation.
f. Adoption.
g. Merging.
h. Swapping.

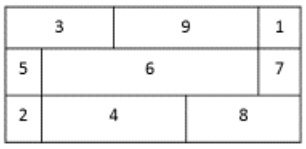

Fig.1 Initial layout Design for the planning period 1

After allocating all the machines in the 3X3 grid determine the centroid of each machineAreas and centroids of the nine machines which are given table 3. Then calculate the distance between the machines by using the formula.

$$D_{j\leftrightarrow k} = |X_j - X_k| + |Y_j - Y_k|$$

For example, distance between machines

$D_{2\leftrightarrow 4} = |1-4| + |2-2| = 3$units

examine the travelling cost of each pair and calculate the total travelling cost for each planning period using the equation (1). Following table 4 gives the total travelling cost for planning period one.

Table.3 Machine numbers areas and centroids for period 1

MACHINE NUMBER	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

AREA		16	8	24	16	8	24	16	24	8
CENTROIDS	X	10	1	3	4	1	5	10	9	7
	Y	10	2	10	2	6	6	6	2	10

Table 4: Total travelling cost for period 1

Ranking	Machine pairs	Flow weights	Distance	Travelling cost
1	2,4	185	3	555
2	5,6	160	4	640
3	2,8	155	8	1240
3	4,6	155	5	775
3	6,7	155	5	775
4	7,8	115	5	575
5	3,5	95	6	570
6	1,7	85	4	340
6	3,8	85	14	1190
6	6,9	85	6	510
7	1,2	70	17	1190
7	2,3	70	10	700
7	3,9	70	4	280
8	5,7	55	9	495
9	1,5	45	13	585
9	2,6	45	8	360
9	2,9	45	14	630
9	5,8	30	12	540
10	1,4	30	14	420
10	2,5	30	4	120
10	6,8	30	8	240
10	8,9	30	10	300
11	2,7	20	13	260
12	1,3	10	7	70
12	7,9	10	7	70
Total travelling cost				15050/-

Similarly, above said procedure is adopted for reaming periods i.e., for 2,3,4 and 5.

4. OPTIMAL LAYOUT DESIGN USING CRAFT ALGORITHM:

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CRAFT begins by determining the cost of the initial layout. It then evaluates all possible location exchanges between pairs of facilities which either are adjacent to each other or are of the same area. The location exchange which results in the greatest estimated cost reduction, is made. This procedure continues until there is no location exchange which results in a lesser cost than that of the current layout. In CRAFT algorithm first step is to interchange the departments based on adjacent boarder or equal area. For each possibility, corresponding centroid and travelling cost is calculated. Next step is to find the pair of department

that corresponds to minimum total travelling cost and it is verified with cost of initial layout design. If it is less than that, the procedure is repeated until cost is greater than the initial layout. Fig.2 shows the steps in the CRAFT algorithm. The layout design is optimized for all the periods using CRAFT algorithm.

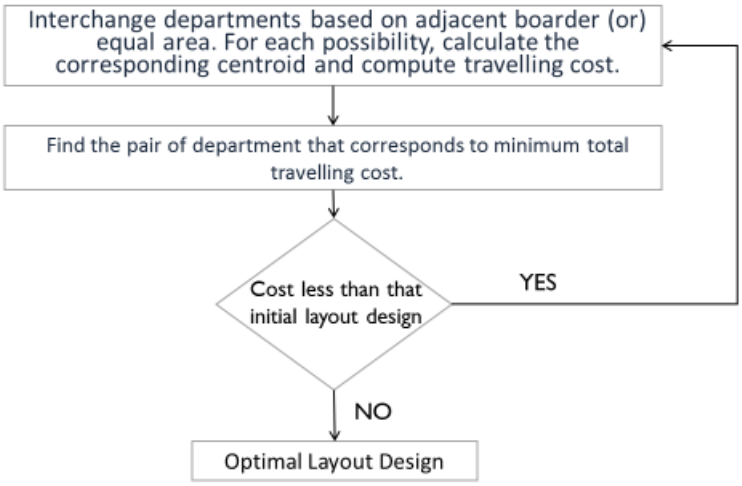

Fig. 2: CRAFT algorithm

5. CONCLUSIONS:

The travelling cost in the initial layout design for all the period is calculated. Initial layout design is optimized using CRAFT algorithm. Comparision of total travelling cost in the initial and optimized layout is shown in Table 5.

Table 5: comparision oftravelling cist of initial layout design and optimized layout for five periods

Period	Travelling cost for initial layout in rupees	Travelling cost for final layout in rupees	Percentage reduction
Period 1	15050	12800	15
Period 2	14310	12240	14.
Period 3	15880	14900	6
Period 4	15345	13550	11
Period 5	11530	10890	6

The total travelling cost in the initial layout for the periods1,2,3,4 and 5 is Rs 15050/- , Rs 14310/-, Rs 15880/- Rs 15345/- and 11530/- respectively. By CRAFT travelling cost is reduced by 15,14,6,11 and 6 % for the periods 1,2,3,4 and 5

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