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Fundamental Approach on Layout Optimization Using Graph Theory in Cellular Manufacturing Systems

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ABSTRACT

An overview of manufacturing and its approach basically works with the calculation to achieve the results as soon possible with best solutions most of the research papers has been published. And the researchers may do so many of experiments and adequate tactic to got better solutions for many of the complex problems in cellular manufacturing systems. With various methodologies and our idea is to be made an integration and new concept exertion in the field of cellular manufacturing by optimize the layout design as a result of shortest path method in graph theory algorithm. We made a conclusion with a layout optimization comparison using ARENA software for better solutions and give better layout design for small scale process industries in that the first step of our research we just made an optimization of layout under our references. Through this paper we exert the project with the optimization of layout related with their material handling distances also with algorithm moaned methodology.

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INTRODUCTION

The facility layout in cellular manufacturing systems involve the arrangement of cells within the floor space, so as to minimize the inter-cell layout movement. The machine layout in cellular manufacturing systems involves the arrangement of machines within the cells so as to minimize the intra-cell movement. Three basic types of machine layout is identified by Hassan.M.M.D (1994). In mathematics and computer science, graph theory is the study of graphs, which are mathematical structures used to model pair wise relations between objects. A graph in this context is made up of vertices, nodes and lines called edges that connect them. The graph may be undirected, meaning that there is no distinction between the two vertices associated with each edge, or its edges may be directed from one vertex to another and it is one of the prime objects of study in discrete mathematics. Layout of the machines within each cell (intra-cell or machine layout) in which the layout involves to deciding where to put all the facilities, machines, equipment and staff in the manufacturing operation within the cell and it determines the way in which materials and other inputs like people and information flow through the operation. Relatively small changes in the position of a machine in a factory can affect the flow of materials considerably. In cellular layout, different types of machines may be arranged in a single row as close as possible to the sequence of operation Cellular Manufacturing (CM) System is an application of the Group Technology philosophy that allows decomposing a manufacturing system into subsystems which makes its management easier than the entire manufacturing system. Implementation of this lean method often represents the first major shift in production activity, and it is the key enabler of increased production velocity and flexibility, as well as the reduction of capital requirements (Dr.V. Anbumalar, *et al*., 2014).

Numerical Illustration:

To illustrate the model, a numerical example is taken from literature. The problem involves 5 parts that are processed in 9machines.Details about the operational sequence quantitative demands and Machine rearrangement cost in a 3 period-planning horizon are furnished in table (Hassan, M.M.D., 1994). The material handling cost per unit distance is taken as 10.In the operational sequence of parts with their production of parts in one day and their quantitative values are clearly shown in that table1 more ever the problem involves in 9 machine we consider the minimum cost for their production the

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major machines are given with in the planning horizon in the static environment.

Table 1: Quantitative Values in static environment

Parts	Period 1	Period 2	Period 3
1	10	35	90
2	30	50	25
3	45	15	40
4	70	80	55
5	85	60	70

Table 2: Comparison between default distance with linear shape single row layouts.

S.no	Sequence of Layout	From paper (distance travelled)	Using Software (distance travelled)
1	1 7 6 5 4 2 8 9 3	4480m	4219m
2	1 4 6 2 7 5 8 3 9	4410m	4198m
3	1 3 5 8 7 9 2 6 4	4940m	3979m

Table 3: Comparison between default distance with L shape single row layouts.

S.no	Sequence of Layout	From Linear layout distance calculation	From L Shape Layout distance calculation
1	1 7 6 5 4 2 8 9 3	4219m	4367m
2	1 4 6 2 7 5 8 3 9	4198m	4218m
3	1 3 5 8 7 9 2 6 4	3979m	4125m

Operational sequence and quantitative demand for various periods are given as inputs. The optimal arrangement of machines and traveling distances for each day in linear single row layout are obtained material handling cost depends on parts to be moved between machines according to the sequence of operation But the transportation cost depends only the movement and flow of materials in a working layout. We have considered the optimum layout sequence with the order for various parts and no of days are given as inputs. The optimal arrangement of machines and traveling distances for each part in linear single row are obtained. And finally compare the results obtained using software from table (Solimanpura M., *et al*., 2004) the travelled distance and their cost for travel in linear row layout is too low and we obtained the optimum cost using the software to find them with minimum travel distance. And the rest of comparisons made with the help of table (Rafiei, H., A. Rahimi-Vahed, 2011) this states the analysis path between default distance with the software calculated distance of L shape layout, Similarly in table (Ahkioon, S., *et al*., 2011) just to find the optimum result we made a distance comparisons between the linear and L shape layouts of this quantitative values in cellular working environment.

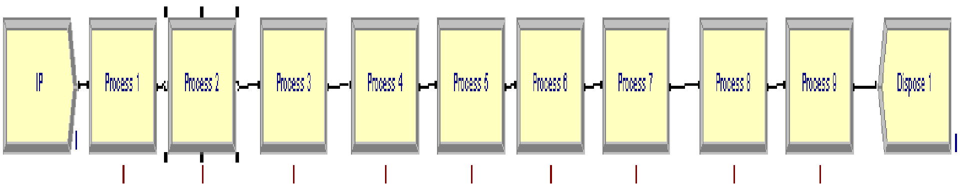

Fig. 1: Arena Linear layout model

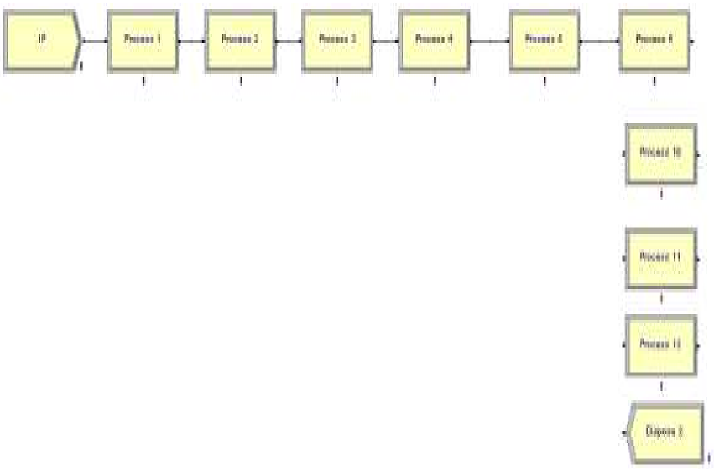

Fig. 2: Arena L shape layout model

M. Solimanpur a (2004) had explained in his paper due to differences in computing facilities, the computation time is not available for some of these heuristics. The computation time of the proposed ant algorithm and the ANTS method both obtained and averaged over five runs of these methods for each problem.

The result which they calculated using algorithm takes more time and calculations also different.But in software they can't face those kind of problems.From their approach we have frame a model using ARENA and find the optimum model with minimum transportation cost. (Rafiei, H., A. Rahimi-Vahed, 2011) Rahimi-Vahed had discuss the novel aspect of this model is concurrently making the interrelated cell formation and intracell layout.

The total cost consists of machine procurement, cell transportation, preventive and corrective repairs material handling (intra-cell and inter-cell), machine operation, part subcontracting, finished and unfinished parts inventory cost, and defective parts replacement costs. With respect to the multiple products, multiple process plans for each product and multiple routing alternatives for each process plan which are assumed in the proposed model, the model is combinatorial. Moreover, unreliability conditions are considered, because moving from "in-control" state to "out-of-control" state (process deterioration) and machine breakdowns make the model more practical and applicable. (Ahkioon, S., *et al*., 2011) T. Bektas in-depth discussions on the trade-off between the increased flexibility in layouts,also increase the transportation cost and distance Even though cellular manufacturing offers huge profit but it is very complex to design cellular manufacturing system for real life problems. Here the cell formation problem and group efficiency is calculated for grouping parts and machines according to SOM techniques and Minkowski distance. First we are using the input machinepart matrix with SOM technique using neural networks to clusters the parts Tribikram Pradhan, (2015) Manufacturing system design has been a challenging issue where various approaches have been proposed in lite rature and implemented in manufacturing industries. Cellular manufacturing system(CMS) design gained popularity due to the increase in product variety and fluctuation in customer demand Gökhan E ğilmez (2015). Now days each and every business focuses their interest particularly on swiftness for answering to their customers' desires. As a result of which they want to amplify response times. Group technology is one of the best strategies to tackle response time in the field of manufacturing, which concentrates on cellular manufacturing. Cell formation is problem refers to the procedure for arranging the part families and machine groups. Cellular manufacturing technique is a substitute to batch- type manufacturing, where dissimilar parts are formed alternatively in small lot sizes Ampazis (2004).

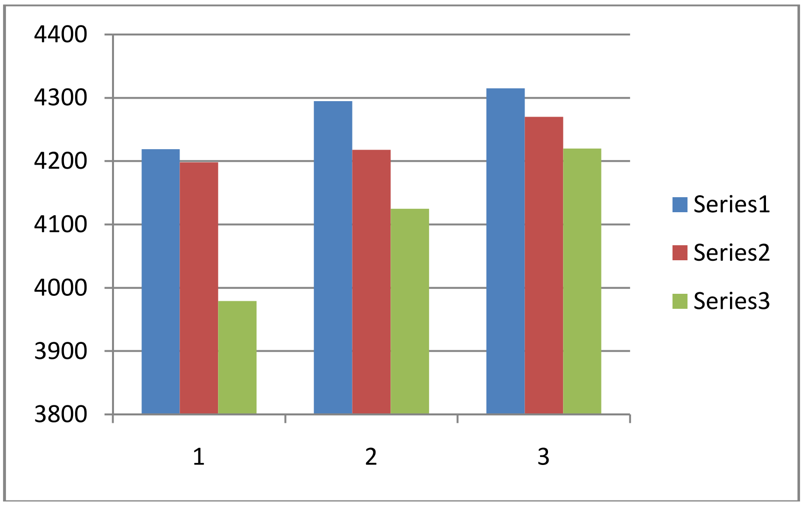

Fig. 3: Comparison of default, linear and L-shape layouts

The above column chart gives the comparison between three layout of three planning period horizon. In this graph no:1 indicates the sequence of layout one and second pair is the combination no:2 which means the optimum design of layout path in all level of comparison that shows through the graphical illustrations no:3 is the details of last sequence of operation always with higher values.this is the simple analysis and easy to find out the optimum layout design and minimum material handling distance between the operations.

Conclusion from the Algorithm with the identification of Shortest Path Method:

Dijikstras algorithm is used to find the shortest Path between any two points or pair between of two vertices of the weighted graph.

Algorithm:

Input:

A Weighted and fully connected graph E and a vertex R of graph E.

Output:

A Spanning tree S of E rooted at vertex labeling to giving the distance from R to all other vertices.

Intialize the dijikstras tree A as vertex R.

Intialize the set of frontier edges for tree A as empty.

Dist (v)=0

Write lable on O vertex R

While dijikstras tree A does not get the span G.

For each frontier edge D for S

Let M be then the labeled end vertex of R

Let N be then the labeled end vertex of R

Set P(e)=dist[M]+w[e]

Let e be a frontier edge for A that has the smallest P value

Let M be then the labeled end vertex of R

Let N be then the labeled end vertex of R

Add edge D and vertex to the tree A

Dist[n] =p(e)

Write label dist [n]on vertex n

Then, Return dijikstras tree A and it's vertex labels.

3. 2 Substitutions and Consequences:

Graph-theoretic methods, in various forms, have proven particularly useful in linguistics, since natural language often lends itself well to discrete structure. Traditionally, syntax and compositional semantics follow tree-based structures, whose expressive power lies in the principle of compositionality, modeled in a hierarchical graph. More contemporary approaches such as head-driven phrase structure grammar model the syntax of natural language using typed feature structures, which are directed acyclic graphs. Within lexical semantics, especially as applied to computers, modeling word meaning is easier when a given word is understood in terms of related words; semantic networks are therefore important in computational linguistics STEP:1 From the given algorithm we consider tree A as the sequence of layout 1-2-3-4-5-6-7-8-9.STEP:2 For the considerations of vertex R to find out the optimum of sequence We enter the three sequence of design as per given,[R1=1- 7- 6- 5- 4- 2-8- 9- 3,R2=1- 4- 6- 2- 7- 5- 8- 3- 9,R3=1- 3- 5- 8- 7-9- 2- 6- 4],STEP:3 Enter the initial distance as 0.Similarly we enter distance of each sequence as [P(Rn)4000m+various distance in m],For different arrangement of operations we have to find the step by step distance in each sequence.STEP:4 From the frontier edge of tree A and vertex of R1,R2,R3.By replacing the different vertex numbers in step 3 we will find out the optimum shortest distance,STEP:5 Dist[R]=P[R]=R2.STEP:6 Return dijikstras tree A and it's vertex labels Rn.

RESULT AND DISCUSSION

Cellular Manufacturing Systems (CMS) is a manufacturing paradigm based on Group Technology (GT). Although both terms CMS and GT are occasionally used interchangeably, GT is an area of study devoted to parts clustering and machine cells formation and considered as the starting point of cell design Iti Dixit[8]. In graph theory, the shortest path problem is the problem of finding a path between two vertices (or nodes) in a graph such that the sum of the weights of its constituent edges is minimized. This will helps to develop this kind of model and improves the level of optimization over layout and its design to easily determine the optimum structure of given problems and to find the solutions using graph theory shortest path method in the field of cellular manufacturing. to easily determine the optimum structure of given problems and to find the solutions using graph theory shortest path method in the field of cellular manufacturing. Especially this method is very useful for layout and sequence optimization in process industry. From the above algorithm and its tree analysis method we found the vertex R2 of all the sequence contains the order as 1- 4- 6- 2- 7- 5- 8-3- 9 resembles the optimum value with minimum material handling distance of 4158 meters between each machine and their operations hence it produce best result in both cases software and algorithm. The proposed algorithm generates a feasible solution by taking into consideration all the alternative routing of each operation & constraint on cell size Gitesh Kumar (2015). The goal of this research is to develop a design methodology that minimizes machine arrangements, if possible means to reduce the inter and intra-cell material handling cost and operating cost by considering alternative routing with different types of layout design to produce optimum distance for all the parameters this help to find out the optimum distance mostly it will improve the production rate and also produce tremendous changes in final output in the process industry.

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