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Job Shop Layout Design Using Group Technology

Gyan Tshering Lepcha, [1] Dr. D.C. Roy[2]
PG Student, Dept. of Mechanical Engineering, Jalpaiguri Govt. Engg.college, Jalpaiguri, India[1]
HOD & Professor, Dept. of Mechanical Engineering, Jalpaiguri Govt. Engg College, Jalpaiguri, India[2]

Abstract: *Every organization needs to remain competent to stay afloat in the sea of competitors with similar products and services. Smaller production companies, such as job shops, are often incapable of committing significant human or capital resources for the improvement of manufacturing flow times. However, there is considerable demand in these organizations for solutions that offer improvements without the risk involved in expending these resources. This paper presents a study that uses simulation to improve shop floor performance by means of certain operational parameters. In this study, an overview of the plant layout problem is covered for the particular company. The original motivation for redesigning the entire shop floor was the need to realize improvements in material flow and output level. Since the machines were scattered this made it very difficult to study the cost involving the flow of materials through these machines. So for the purpose of analyzing total material handling cost, 34 elements (jobs) were taken which are mainly processed through 6 machines, out of which 32 elements were divided into 4 part families using Direct Clustering Method (DCM) with group technology concept method and similar machines were arranged together to analyze the cost using Computerized Relative Allocation of Facilities Technique (CRAFT) with aide of computer graphics .Finally, a new job shop layout was designed, which yield minimum material handling cost.*

Keywords: *Job shop, Direct Clustering Method (DCM), Computerized Relative Allocation of Facilities Technique (CRAFT), Group Technology.*

I. Introduction

In the job shop environment, the need to improve manufacturing flow times has always been a critical factor to stay competitive. Simply adding human resources or capital equipment may improve flow times, but these alternatives can add tremendous fixed cost and risk to an organization. Most job shops cannot afford the investment needed to reduce their manufacturing flow time. Therefore, a more economical alternative would be of great value to smaller organizations.

In this study, a haphazard arrangements of machines in job shop was clubbed together to form separate machine cells and various layout was designed to investigate improvements in material flow and output level.34 elements were taken which are processed through six machines- lathe, milling, grinding, slotting, shaping and drilling. Other objectives of the study can be summarized as follows:

- To determine the inherent constraints and the bottlenecks in manufacturing process.
- To increase the percentage of annual production quantity completed on time without extra costs including subcontracting and overtime costs.
- To provide a solid base for supervision and face-to- face communication.

II. Design of the Study

To achieve the objectives of the study, the requirements of the following five steps were sequentially satisfied:

1. Part families were formed using Direct Clustering Method (DCM*)*.
2. Similar machines were grouped together to form separate departments.
3. Physical layout of machines (intra-cell) and cells (inter-cell) were developed by means of powerful and well known CRAFT algorithm, which is the basis for many computer-aided layout programs.
4. New manufacturing system was modeled and analyzed to determine the system performance according to predetermined performance measures.
5. Final layout with optimum cost was developed.

III. Part Family Formation & Layout Design for Grout Technology Layout

According to Fraizer and Spriggs (1996), a GT layout is most appropriate for batch processing because parts are produced in small to medium batches and there is relative stability in the product mix. The GT cell creates a small, cost-effective assembly line within the production operation, but provides much more flexibility than traditional assembly lines. Because each cell is dedicated to producing a group or family of similar parts, switching between similar parts in the family is quick and easy. Only minimal setup time is required, compared with a changeover on an assembly line or with a traditional batch processing or job shop.

3.1. Part family Formation

For the part family formation Direct clustering Method was used

Step1. Calculate weight of each row,

$$w = \sum M$$
$$w_j = \sum_i M_{ij}$$

Step2. Sort rows in descending order

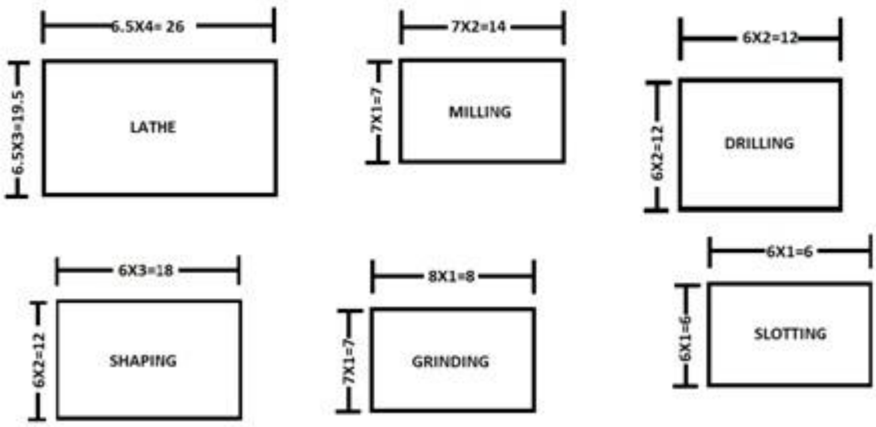
Step3. Calculate weight of each column,
Step4. Sort columns in ascending order
Step5. For I = 1 to n, move all columns j where Mij = 1, to the right while maintaining the order of the previous rows.
Step6. For j = m to 1, move all rows I, where Mij = 1, to the top, maintaining the order of the previous columns.
Step7. If current matrix = previous matrix, STOP; Else go to Step 5.

MACHINES \ JOBS	11	19	28	29	14	16	26	27	30	17	18	20	12	15	24	1	2	3	4	6	7	9	21	22	23	25	5	8	10	13	31	32	33	34	RANK
Milling	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1
Slotting	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	2
Lathe	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	3
Shaping	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	4
Grinding	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	5
Drilling	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	6

Therefore following Four part family is formed by using Direct Clustering method. Job 11,19 ,28 and 29 were omitted from part family, since there was no movement from one machine to other.

3.2. Layout Design

After the formation of Part families it has been seen that different members of part family consists six machining operations as a whole–Lathe , Milling, Grinding, Shaping, Slotting and Drilling.



IV. Optimizing the Job Shop Layout

For the opmization of plant layout, Computer Relative Allocation of Facility Technique (CRAFT) with aide of computer graphics simulation was used.

CRAFT is one of the important computer programmes for the quantitative solution of process layout program. The program works in the following manner:

(a) An initial layout is given along with the problem.
(b) The load summary i.e. the to and fro movement frequencies between the various pairs of departments is also supplied.

The interdepartmental pair wise costs per unit distance are also given.

(c) With (a) and (b) as the inputs, CRAFT now interchanges a pair of departments which have
(i) either a common border, or
(ii) The same area requirement.

This is done by interchanging the centroid locations of the departments rather than an actual physical change. CRAFT considers centroid rectilinear distances for the cost computations.

(d) Having done this interchange of centroids it calculates the total costs for the modified layout.
(e) All possible pair wise interchanges are done and costs computed as in (c) and (d).
(f) The least cost interchange is then accepted.
(g) This interchange, i.e. the interchange in step (f) above is now done physically i.e. by physically interchanging the areas.

This may change actual centroid locations and intercentroid distances and therefore the total cost. This is the real cost.

(h) CRAFT now applies the pairwise interchange to the improved layout. That is step (c) through (h) are repeated until no further cost reduction is possible by the pairwise interchange of the centroids.
(i) The last layout is the solution obtained through CRAFT.

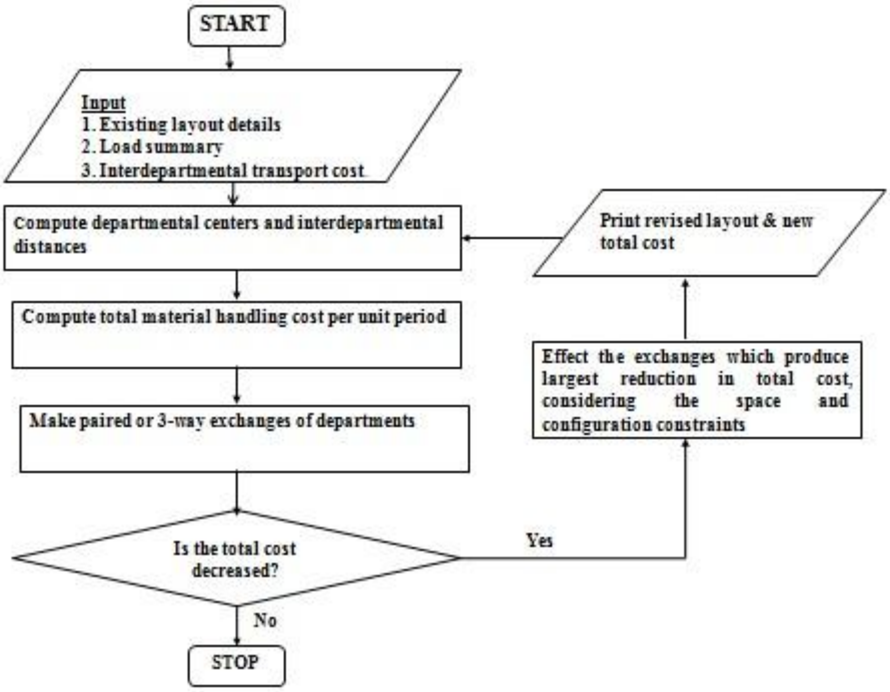
4.1. Criterion for Comparison

The flow multiplied by the distance and summed over all cells of the chart. We compute the cost for the flow from *i* to *j* as the product of the material handling cost, the flow and the distance between the departments. The cost of the layout is the sum of the flow cost.

$$\text{Min. } z = \sum_{i=1}^{n}\sum_{j=1}^{n} c_{ij} f_{ij} d_{ij}$$

Where c_{ij} = Material handling cost matrix per unit
f_{ij} = Load matrix
d_{ij} = distance matrix

4.2. Flow chart of CRAFT



4.3. Input Data

To ascertain these results, actual data from a job shop was used to aid in developing a simulation of their shop layout

4.3.1. Initial layout

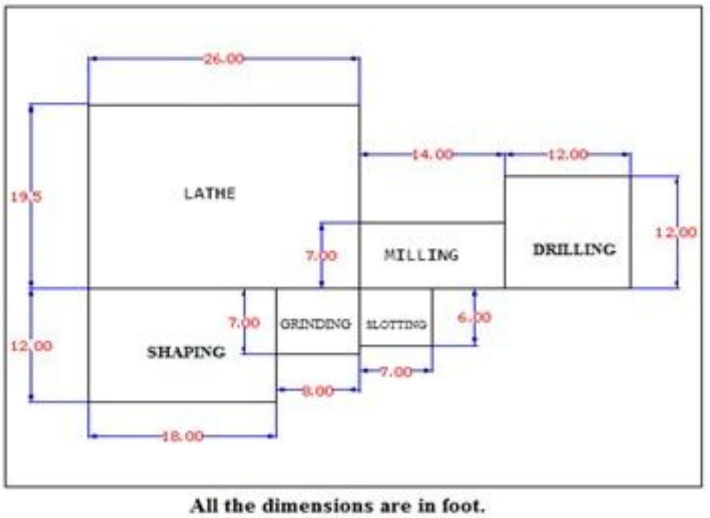


Fig1. Initial layout

Table I: Load matrix

	LATHE	SHAPING	MILLING	GRINDING	DRILLING	SLOTTING
LATHE	-	0	17	0	4	4
SHAPING	-	-	0	4	0	0
MILLING	-	-	-	6	3	4
GRINDING	-	-	-	-	4	0
DRILLING	-	-	-	-	-	0
SLOTTING	-	-	-	-	-	-

Table II: Cost matrix

	LATHE	SHAPING	MILLING	GRINDING	DRILLING	SLOTTING
LATHE	-	1	1	1	2	2
SHAPING	-	-	2	1	3	2
MILLING	-	-	-	2	1	1
GRINDING	-	-	-	-	3	1
DRILLING	-	-	-	-	-	2
SLOTTING	-	-	-	-	-	-

Table III: Distance Matrix (Initial Layout)

	LATHE	SHAPING	MILLING	GRINDING	DRILLING	SLOTTING
LATHE	-	19.75	26.25	22.25	36.75	28.75
SHAPING	-	-	33.5	15.5	49	23
MILLING	-	-	-	18	15.5	10.5
GRINDING	-	-	-	-	33.5	7.5
DRILLING	-	-	-	-	-	26
SLOTTING	-	-	-	-	-	-

V. Results

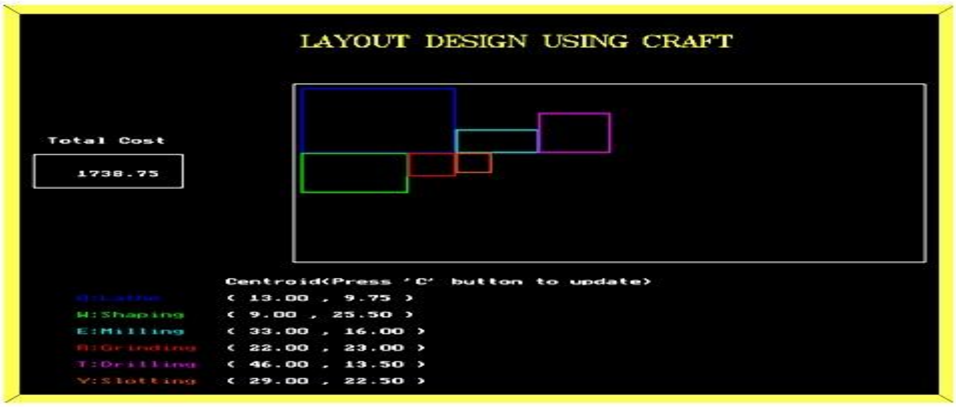


Fig.2. Simulation output for initial job shop layout

Total Cost (Initial Layout) = 1738.75 Units/Unit period

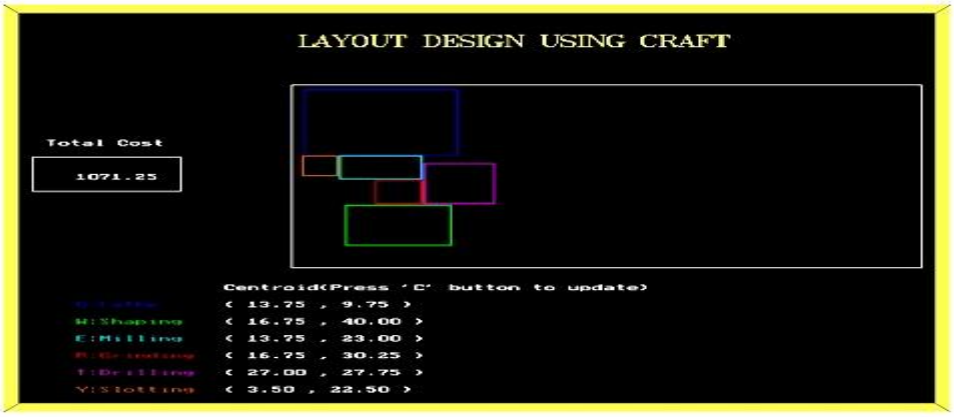


Fig.3. Simulation output of final layout (optimum layout)

Total Cost (Optimum Layout) = 1071.25 Units/Unit period

Table IV: Distance Matrix (Optimum Layout)

	LATHE	SHAPING	MILLING	GRINDING	DRILLING	SLOTTING
LATHE	-	33.25	13.25	23.5	31.25	23
SHAPING	-	-	20	9.75	22.5	30.75
MILLING	-	-	-	10.25	18	10.75
GRINDING	-	-	-	-	12.75	21
DRILLING	-	-	-	-	-	28.75
SLOTTING	-	-	-	-	-	-

VI. Discussion

By reconfiguring the machines of job shop by CRAFT method with incorporation of graphics simulation there was a huge reduction in total material handling cost i.e., from 1738.50 Units/Unit period (initial) to 1071.25 Units/ Unit period. The cost was calculated for the single unit of each item. So, this result will be more vital and profitable when the number of units of the items increases.

VII. Conclusion

This study was aimed at identifying alternative configurations of job shops without investing in additional capital or human resources, and by using layout design technique with incorporation of computer graphics programming. After collecting actual data of 32 jobs, a simulation model was developed to approximate the actual shop environment. Based on the results from this initial model, an optimum layout is developed. This final layout that incorporates group technology concept provides an optimum cost. This study shows that total material handling cost can be improved without investing in additional resources. The results are significant for job shops, especially smaller production firms that cannot afford to continually invest in new equipments and hire additional workers. The reconfiguration of floor shop into a group technology environment can reduce total material handling costs, thus improving the profit to the organization. This assist job shops in remaining competitive in the market.

VIII. Acknowledgements

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