CASE STUDY ON PLANT LAYOUT OPTIMIZATION USING RANK ORDER CLUSTERING METHOD

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Abstract:

With rapid increasing of demand in production, industrial factories need to increase their potentials in production and effectiveness to compete against their competitors. At the same time, the production process needs to be equipped with the ability to have lower cost with higher effectiveness. Therefore, the way to solve the problem about the production is very important. There are many ways i.e. quality control (QC), total quality management (TQM), stand cycle time, plant layout to solve the problems concerning productivity. “Plant layout is plan of an optimum arrangement of facilities including personnel, operating equipments, storage space, material handling equipments and all other supporting services along with the design of best structure to contain all these facilities.” Our research work is basically related to material handling cost reduction; and to reduce the material handling cost we have selected the solution as a plant layout re-design. As there are 18 machines in workplace to find optimized path for Operations we need to find 18! Solutions and it is difficult to solve manually. Hence Cellular manufacturing, Group technology, Rank order clustering methods are used in finding out the best optimized path.

Keywords: **Cell, Classification**, **Cluster analysis**, **Coding**, **Group technology, Production flow analysis**

Introduction:

Plant layout refers to the physical arrangement of production facilities. It is the configuration of departments, work centers and equipments in the conversion process. The overall objective of plant layout is to design a physical arrangement that meets the required output quality and quantity, most economically. According to the many researchers plant layout is one way to reduce the cost of manufacturing and increasing the productivity, which also increases good workflow in production route. This analysis describes original plant layout, material flow analysis, which includes are and distance between operations A and B. It was found that there was wasted time and delay in manufacturing i.e. the movement of the material in long line and interrupted flow as well as useless area of the plant. According to these problems, we have analyzed the way to solve such problems and fond the way to improve the plant layout. The optimization technique is used to modify the existing plant layout. The new plant layout that improves the process flow through the plant, and helps to reduce material handling cost has been recommended. Layout problems are found in several types of manufacturing industries. . It is the identification and bringing together related or similar parts and processed, to make advantage of

similarities exist, during all stages of design and manufacture. In case of Rank Order Clustering, the production addressed here is determining how machines in existing plant should be grouped into machine cell. The problem is same whether the cells are virtual or formal. It is basically the problem identifying part families, after part family can be selected and grouped together. Manufacturing with GT cells is called as cellular manufacturing. The identical or specific number of cells is to be formed by use of GT data. So according to cells the machines are arranged and operations are grouped. Hence by following these methods we have found out the best optimized path for reducing material handling cost to great extent and eventually lead to increase in productivity.

Problem Identification:

Identified the following problems in the company:-

1. Random orientation
   The machines are randomly arranged. Machines are not arranged sequentially according to their uses.
2. High material handling
   Random arrangement causes large distance to be travelled and this leads to high material handling cost.
3. Long cycle time
   Due to large distance travelled between machines time required is more to complete the product.

Possible solution:

The possible solutions for the above stated problem are:

Automation, Use of special purpose machine (SPM), Deploy Equipment, Redesigning of plant layout

Finalizing solution

By thoroughly studying and analyzing all above possible solutions we have decided for redesigning of plant layout as a final solution.

Objectives of Plant Layout

The objectives of plant layout are:

1. Streamline the flow of materials through the plant.
2. Facilitate the manufacturing process.
3. Maintain high turnover of in process inventory.
4. Minimize materials handling.
5. Effective utilization of men, equipments, and space.
6. Make effective utilization of cubic space.

Methodology

Group Technology (GT)

Group Technology (GT) is a processing philosophy based on the principle that similar products should be processed similarly (Ask in and Stand ridge, 1993). The basic idea of GT is to decompose a manufacturing system into subsystems. It reduces (Kusiak, 1990) production lead time; work-in process; labor; tooling; rework; scrap material; set-up time; delivery time; and paper work. The idea behind GT is to improve efficiencies by exploiting similarities. The application of GT influences time power of operation, WIP inventory, material handling, job satisfaction, jig and fixture, set up time, required

space, quality, finished product and labor cost (Wemmer and Hyer, 1998). This concept has been successfully employed in cellular manufacturing in which, parts with similar processing requirements are identified and grouped into part families, and then machines with different processing capacities are placed within a cell.

Optimization Techniques:

To find the optimized path to reduce material handling, optimization is one of best option. We have used optimization technique to re-design the existing path layout for the purpose of material handling cost reduction manufacturing time. Brief introduction of Optimization techniques is given below:

3.3.1 Cellular Manufacturing:

Grouping Machines logically so that material handling (move time, wait time for moves and using smaller batch sizes) and setup (part family tooling and sequencing) can be minimized. Cellular manufacturing (CM) has materialized as a viable replacement to these which is the application of group technology (GT), a philosophy that utilizes similarities in product design and production processes. The CF problem has long been identified as the most icky problem in grasping the concept of CM, which begins with two fundamental tasks, (i) machine-cell formation, where similar machines are grouped and dedicated to manufacture part-families. (ii) part-family construction, where parts with similar design, features, attributes, shapes are grouped and manufactured within a cell.

Optimization

Rank Order Clustering:

King (1980) presented a simple algorithm for converting a part machine incidence matrix in to a nearly block diagonal structure. A block diagonal matrix is one where boxes on the main diagonal contains ‘0’s and ‘1’s, while the off diagonal boxes contain all ‘0’s.In this procedure ,the rows and columns are considered as binary strings ,left to right for rows, and top to bottom for columns. ROC carried out in steps given below:

1. In each row of matrix read the series of 1's & 0's from left to right as a binary number, Rank the row in order of decreasing value. In case of tie, rank the rows in same order as they appear in current matrix.
2. Numbering from top to bottom is current order of rows the same as the rank order determined in the previous step if yes go to step 7 if no go to following step.
3. Reorder the rows in part machine incidence matrix by listing them in decreasing rank order starting from the top.
4. In each column of matrix read the series of 1's & 0's from the top to bottom as a binary number. Rank the column in order of decreasing value. In case of tie, rank the rows in same order as they appear in current matrix.

5. Numbering from left to right is current order of column the same as the rank order determined in the previous step if yes go to step 7 if no go to following step.
6. Reorder the columns in part machine incidence matrix by listing them in decreasing rank order starting from with left column, go to step 1.
7. Stop.

In our case there are 23 machines & 13 products so part-machine incidence matrix is shown below.

Part-Machine Incidence Matrix

Product Names ⟹

	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13
P1	0	1	1	0	0	0	0	0	1	0	0	0	0
P2	1	0	0	1	0	0	1	0	0	0	0	0	0
P3	0	0	0	0	0	0	0	1	0	0	0	0	0
P4	0	0	0	0	0	0	0	1	0	0	0	0	0
P5	1	1	1	1	0	0	1	0	0	0	0	0	0
P6	0	1	1	0	0	0	0	0	0	0	0	0	0
P7	1	0	0	0	0	0	1	0	0	0	0	0	0
P8	0	0	0	0	0	0	0	0	0	0	0	0	0
P9	0	0	0	0	0	0	0	1	0	0	0	0	0
P10	0	0	0	0	0	0	0	1	0	0	0	0	0
P11	0	0	0	1	1	1	0	1	0	1	1	1	1
P12	0	0	0	0	1	1	0	0	0	0	1	1	1
P13	0	0	0	1	1	0	0	0	1	0	0	0	0
P14	1	0	0	1	0	1	1	0	1	0	0	0	0
P15	1	0	0	0	0	0	1	0	0	0	0	0	0
P16	0	1	1	0	0	0	0	0	0	0	0	0	0
P17	0	0	0	0	0	0	0	0	0	0	0	0	0
P18	0	0	0	0	1	1	0	0	1	0	1	1	1
P19	0	1	1	0	1	0	0	0	0	1	0	0	0
P20	1	1	1	0	0	0	1	0	0	0	0	0	0
P21	1	0	0	0	0	0	1	0	0	0	0	0	0
P22	0	0	0	0	0	0	0	0	1	0	1	1	1
P23	0	0	0	0	0	0	0	0	1	1	0	0	0

After grouping machines & parts by rank order clustering we get the matrix as shown below

Part-Machine Incidence Matrix after ROC

Product Names ⟹

	J2	J3	J1	J7	J4	J9	J5	J10	J6	J11	J12	J13	J8
P5	1	1	1	1	1	0	0	0	0	0	0	0	0
P20	1	1	1	1	0	0	0	0	0	0	0	0	0
P1	1	1	0	0	0	1	0	0	0	0	0	0	0
P19	1	1	0	0	0	0	1	1	0	0	0	0	0
P6	1	1	0	0	0	0	0	0	0	0	0	0	0
P16	1	1	0	0	0	0	0	0	0	0	0	0	0
P14	0	0	1	1	1	1	0	0	1	0	0	0	0
P2	0	0	1	1	1	0	0	0	0	0	0	0	0
P7	0	0	1	1	0	0	0	0	0	0	0	0	0
P15	0	0	1	1	0	0	0	0	0	0	0	0	0
P21	0	0	1	1	0	0	0	0	0	0	0	0	0
P13	0	0	0	0	1	1	1	0	0	0	0	0	0
P11	0	0	0	0	1	0	1	1	1	1	1	1	1
P18	0	0	0	0	0	1	1	0	1	1	1	1	0
P23	0	0	0	0	0	1	0	1	0	0	0	0	0
P22	0	0	0	0	0	1	0	0	0	1	1	1	0
P12	0	0	0	0	0	0	1	0	1	1	1	1	0
P3	0	0	0	0	0	0	0	0	0	0	0	0	1
P4	0	0	0	0	0	0	0	0	0	0	0	0	1
P9	0	0	0	0	0	0	0	0	0	0	0	0	1
P10	0	0	0	0	0	0	0	0	0	0	0	0	1

Cell Formation

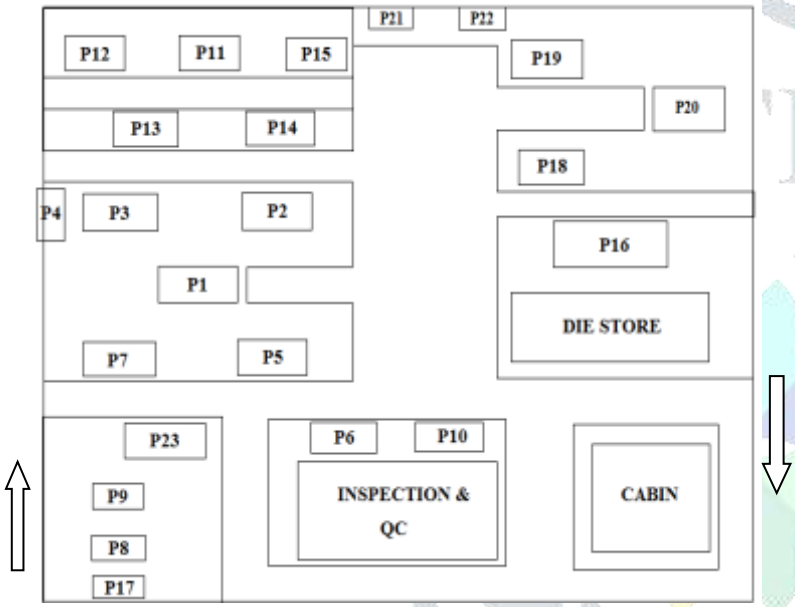
CELL NO.	MACHINES	PRODUCTS
1	P5 – P20 – P1 – P19 – P6 – P16	J2, J3
2	P14 – P2 – P7 – P15 – P21	J1, J7
3	P13 – P11 – P18 – P23 – P22 – P12	J4, J9, J5, J10, J6, J11, J12, J13
4	P3 – P4 – P9 – P10	J8

Project Consideration

a) The layout is product or line layout.
b) The distance calculation between machines/departments is done by using rectilinear distance method.
c) The boundary shape of layout is rectangular; however it can be applied in any irregular shape of area.
d) Minimum material handling cost is considered as criterion for optimization.
e) Group Technology (GT) is used as an optimization tool.

Existing plant layout study

The existing plant layout is shown below



Current Layout of Company

Inter departmental distance calculation

The machines are arranged on the basis of load or capacity of machines without any constraints. There was no passage and inter structural wall in the layout so distance between two machines / departments was easily measured by rectilinear distance method. In this method, distance between two machines / departments / facilities is measured along path that is orthogonal to each other. The rectilinear distance was measured by assuming the block area equal to the total machine size and surrounding. As per the original layout approximate dimensions are taken.

Flow diagram

As the name suggest is a chard or record of the amount of travel by the material in-process while going from machine to machine or from one department to another. The amount of travel depends upon the movements and distance between the sections or departments. These charts are used to improve the existing plant layout.

Operation flow chart

Products	Sequence of Operations							Quantity
J1	P20	P2	P14	P21	P7	P5	P15	70000
J2	P20	P1	P5	P16	P19	P6		10000
J3	P20	P1	P5	P16	P19	P6		8000
J4	P13	P11	P2	P14	P5			10000
J5	P13	P11	P12	P18	P19			5000
J6	P12	P11	P11	P18	P14			40000
J7	P20	P2	P14	P21	P7	P5	P15	35000
J8	P4	P3	P8	P9	P10			8900
J9	P13	P22	P1	P18	P14	P1	P23	4000
J10	P19	P23	P11	P11				8000
J11	P22	P18	P12	P11	P22			600
J12	P22	P18	P12	P11	P22			600
J13	P22	P18	P12	P11	P22			600

GT Optimization

GT is an optimization tool used for plant layout redesign.

CELL NO.	MACHINES	PRODUCTS
1	P5 – P20 – P1 – P19 – P6 – P16	J2, J3
2	P14 – P2 – P7 – P15 – P21	J1, J7
3	P13 – P11 – P18 – P23 – P22 – P12	J4, J9, J5, J10, J6, J11, J12, J13
4	P3 – P4 – P9 – P10	J8

Optimized Layout Using GT:

According to result obtained by GT, if sequence of machines is changed then layout of plant will change to as shown in fig. Material Handling cost calculated as 0.01 per paisa per feet.

In optimized layout, machines are arranged in one line depending upon the sequence of operations required for the product. The materials move from one workstation to another sequentially with minimum backtracking or deviation. The raw material moves very fast from one workstation to other stations with minimum work in progress storage and material handling,

Total distance travelled in workplace (Optimized Layout)

Product Name	Operation Sequence							Distance Travelled	Total Quantity	Total Distance Travelled (feet)
J1	25.71	14.35	12.1	12.7	50	42.6		157.4	70000	11018000
J2	11	41.1	41	25.1	29			147.2	10000	1472000
J3	11	41.8	41.05	25.1	29			147.2	8000	1177600
J4	40.7	33	9.3	63.31				146.3	10000	1463000
J5	40.7	12.8	23.4	49.11				126	5000	630000

J6	12.8	35	49.11					96.8	40000	3872000
J7	25,71	14.35	12.1	12.7	50	42.6		157.4	35000	5509000
J8	13.35	28.4	33.9	6.9				82.5	8900	734250
J9	32.6	54.21	61.21	26	40			243.23	4000	972920
J10	26	12						38	8000	304000
J11	7	23	10.8	34.2				74.2	600	44520
J12	7	23	10.8	34.2				74.2	600	44520
J13	7	23	10.8	34.2				74.2	600	44520
Total										27286330

Again the material handling charges are considered as Rs. 0.01/ per piece, per feet then total material handling cost (MHC) for Optimized Layout is Rs. 27286330.

Comparison of Original/Current Layout with Optimized Layout

	Original Layout	Optimized Layout	Change in cost as compared to original layout	% Saving
MHC (1paisa / ft/piece)	35352300	27286330	(35352300-27286330) = Rs. 8065970 (i.e. saving)	$\frac{8065970 * 100}{35352300}$ = 22.81%

Conclusion:

Existing plant layout has been modified by using cellular manufacturing technique and considering material handling cost as the criterion. By implementing the improved layout, the material handling cost is reduced by Rs. 26886.56 per day (8065970/annual). According to the proposed layout, there is total 22.81% saving which is achieved in material handling cost.

Therefore the company can adopt the improved layout to reduce material handling cost. This results in savings of amount of resources used, which can be utilized in increasing the numbers of movements per day or for other activities of the process. As a result cycle time reduces and the overall productivity will be increased.

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