Available online at www.ijiere.com

International Journal of Innovative and Emerging Research in Engineering

e-ISSN: 2394 - 3343 p-ISSN: 2394 - 5494

Studies for Restructuring of Indian Auto Industries Plant Layout based on Cell Formation

Jayant H.Bhangale[a], Ashish M. Mahalle[b]

[a]Ph.D. Scholar 1, Laxminarayan Institute of Technology, Nagpur, Maharashtra, India

[b]Head of Dept.- General Engg. 2, Laxminarayan Institute of Technology, Nagpur, Maharashtra, India

ABSTRACT:

Presently, most of the companies have combination of process and product layout. Cellular manufacturing is a place where company has established one or more manufacturing cells. Companies like Sharda Motors, M &M are in changing phase for improvement. Problems identified in existing layout are low manpower utilization, more time for material handling, high WIP inventory and space utilization. The objectives of the research are to reduce through put time, to increase the target of manufacturing component and completion of target as per demand, to maximize manpower utilization, to minimize space utilization, to reduce manpower requirement. The methodology adopted is analysis of existing layout, then comparing it with analysis of Cellular layout. From the study and analysis it is found that manufacturing time / component (min.) reduces upto 11 min., increase in manpower utilization to 92%, saving in Space Requirement upto 130 square meter, 06 months payback period for CMS setup, reduction in pallet requirement upto 04 and Standard time reduces in new cellular layout.

Keywords: Automobile firm Plant Layout, Cell Design, and Restructuring.

ABBREVIATION

WIP-Work-in-progress
CMS-Cellular manufacturing system
AGV-Automated guided vehicle

I. INTRODUCTION

Most efficient manufacturing system, the assembly line, is in fact a cell. Distinctions can also be made between cells that process part and those that oriented toward products. A product cell is either a pure assembly cell or a combination of an assembly and a fabrication / machining cell. A part cell, on the other hand, only handles fabricated and machined single parts.

Cells can also differ with respect to their internal flow patterns. The flow line cell is the ideal for manned cells due to its simplicity (the layout is not necessarily linear; in fact, the U-Shaped cell is more common and has the advantage of regarding the distances inside the cell for operators and materials handling equipment). Material never backtracks and confusion and scheduling decisions are avoided. On the other extreme is the job shop cells where the flow patterns can look quite complicated. Such patterns are not uncommon for automated cells where the computer schedules and controls all movements. However, in manned cells such flow pattern creates low job status visibility and control problems.

II. LITERATURE REVIEW

The work of Agrawal states that balancing the work load among the machines will indirectly enable to reduce the inventory and will also help in multi-machine tending by the operators [1].

Cell formation problem (CFP), as one of the most important decision-making problems in designing a cellular manufacturing system (CMS), includes grouping the machines in cells and the parts as part families. In CFP, machines and their capacity are of the most important issues being considered carefully. Another significant aspect of the problem is material handling costs, namely intercellular and intracellular movement costs with respect to machines layout. [2].

The primary focus of cell formation research is grouping parts into part families and machine into machine groups in order to create manufacturing cells such that one or more criteria are optimized. Considering multiple objectives makes the problem more complex and a better approach is required to solve for optimal solution [3].

Cellular manufacturing system has been implemented to reduce motion, transportation wastes, workers salary and their requirement. Efforts are made to design, analyze and simulate the performance using “WITNESS” software [4].

So, acute need is to develop the models to specify the optimal number of groups and optimal production mix subject

to technological and logistical constraints for optimal performance of cellular manufacturing system. There is a need to develop more efficient tools enabling manufacturing system designer to achieve optimal solution in reasonable processing time [5].

Developing a group of machine cells and their corresponding part families to minimize the inter-cell and intra-cell material flow is the basic objective of the designing of a cellular manufacturing system (CMS). Afterwards achieving a competent cell layout is essential in order to minimize the total inter-cell part travels, which is principally noteworthy [6].

Productivity can be increased by reducing non value adding process which can be identified through seven wastes (defects, inventory, motion, waiting, over processing, overproduction, transportation) and through work study. Cellular layout is a manufacturing philosophy in which similar parts are identified and grouped together to take advantage of their similarities in design and production [7].

An optimum solution to a layout problem might maximize the output of a given set of facilities with little regard to overall costs. Of course, it was the urgent demand for war materials that brought about this rather unusual situation [8].

This study considers machine component grouping problems namely inter-cellular movement and cell load variation by developing a mathematical model and optimizing the solution using Minimization of cell load is ideal where balancing work load with in cell design or when there is restriction on the available working time period [9].

Job shops and flow lines cannot meet today's production requirements where manufacturing systems are often required to be reconfigured to respond to changes in product design and demand. As a result, cellular manufacturing (CM) emerged as a promising alternative manufacturing system identifying similar parts and grouping them together into families to take advantage of their similarities in design and manufacturing [10].

The tenet of CM is to break up a complex manufacturing facility into several groups of machines (cells), each being dedicated to the processing of a part family. Therefore, each part type is ideally produced in a single cell. Thus, material flow is simplified and the scheduling task is made much easier [11].

Reductions in manufacturing throughput time can generate numerous benefits, including lower work-in-process and finished goods inventory levels, improved quality, lower costs, and less forecasting error (because forecasts are for shorter time horizons). More importantly, reductions in manufacturing throughput time increase flexibility and reduce the time required to respond to customer orders as demonstrated by [12].

Some of the parameters important for relocation and change are throughput time, WIP inventory, number of fixtures for cell parts, setup time, space needed, finished good inventory, labor costand response time to orders [13].

III. METHODOLOGY

The methodology adopted to achieve the objectives is as follows:

a) Studying the existing layout.
b) Identifying operation sequence & elemental Operation time details for each machine.
c) Calculation of machine capacity for each machine.
d) Developing suitable cellular layout for each production line in cellular layout.
e) Calculation of manpower utilization for each production line in cellular layout.
f) Determination of standard time for each production line in cellular layout.
g) Determination of material handling route for each production line in cellular layout.
h) Determination of WIP inventory and pallets requirement for each production line in cellular layout.
i) Analysis of Cellular layout - i.e. cost analysis.

IV. EXISTING LAYOUT

Existing layout is a combination of process and product layout (i.e. processing takes place in sequential order and final product comes out). On assembly line of Exhaust system, three components are made.

a) Muffler Assembly Line
b) Tail Pipe Assembly Line
c) Front Pipe Assembly Line

In existing layout one man operates one machine. Existing layout and material flow in existing layout are shown in Fig.1 Details about operation number, operation, machine and number of machines used for Muffler Assembly Line, Tail Pipe Assembly Line and Front Pipe Assembly Line are given in Table1.

For performing the operation, company gives 17% allowances. According to that standard time can be calculated as

Standard Time = Basic time + (0.17 X basic time).
Standard Time = 1.17 x Basic time.
Based on standard time, company gives target to the operator.
In Tail Pipe assembly line, for Operation number 20 (Rough and Finish mill on Joint face)
Standard time is 3.05 min. per component.
Target for operator = 480 min/4.70 = 102 components / shift.

In existing layout production takes place based on monthly requirement i.e. shift wise production does not takes place on each machine. In Muffler assembly line, for operation number 20, standard time = 2.29min. and target for one shift = 209 component. Operation number 30, standard time = 1.33 min. and target for one shift =360 component. Therefore for operation number 20, it takes more than two times that required for operation number 30. Seven operators are required for production of 3000 component in month (25 days).

Table 1. M*anpower utilization for existing layout*

MONTH	4	5	6	7	8	9	10
%UTILIZATION	63%	63%	64%	72%	72%	69%	72%

Line	Operator	I/P Hrs.	Unplaned & Others Hrs.	Absent Hrs.	Total Hrs.	%Utilization
MUFFLER	7	928	338	22	1288	72%
TAIL PIPE	4	538	186	12	736	73%
FRONT PIPE	8	1045	391	36	1472	71%
TOTAL	19	2511	915	70	3496	72%

Manpower utilization = Input hours / Total available hours.
Total available hours = Total hours – Absent hours.
Unplanned and other hours: Machine breakdown, machine trial, setting of tools,
Industrial department study, unplanned and unmeasured hours etc. (Refer Table1)
a) Operation time details
Operation time details for operations in Muffler Assembly Line are given in Table3. Operation time details are as follow,
1) Handling time: Time required for unloading, loading, inspection, checking by GO-NOGO gauge.
2) Tool change time (T. C. T.): Time required changing tool after completion of its life. Tool life means number of component produce by the tool within specific limit before change of tool. [TCT = Time for toll change / Life (Number of components)]
3) Element time:
Machine cycle time: When only machine engage.
Inside time (I): When operator and machine both engage.
Outside time (O): Whatever activities done by operator externally during auto cycle.
Walking time (W): Time required for person to walk from one machine to other.
Tool change time (TCT): Time required for changing tools.
Homing time (Reference time): Time required setting X, Y, Z – axis on machine.
4) Total manual time (TMT): Time required for operator to produce one component.
[TMT = I + O + W + TCT + HT]
5) Control cycle time (CCT): [CCT = M + I + TCT + HT].
b) Machine capacity calculation
In existing layout machine capacity is calculated as
Machine capacity = Machine time available / Control cycle time.
Shift = 08 Hrs. = 480 Min. = 28800 Sec.
Working time available /Shift = 7.5 Hrs. = 450 Min. = 27000 Sec. {0.5 Hr. = [05 Min. for In and Out time per shift + (10 Min. for Tea Break X 02 Tea Break)]}
Machine time available = No. of m/c x 2 shift x 450 Min.
Production Volume = 4550 Muffler assembly set / Month (considering maximum volume required from customer/month in a year plan)
= 4550/26 working days = 175 sets/day
Demand based cycle time (DBCT) = (2 Shift x 450 Min.) / 175 = 5.14 Min.
No. of operator required = TMT/DBCT.
1) Front Pipe assembly line = 43.45/ 5.14 = 8.45 = 09 operators
2) Tail Pipe assembly line 15.59/5.14 = 3.03 = 04 operators
3) Muffler assembly line = 29.35/5.14 = 5.71 =06 operators
c) Production volume
Depending on market demand, number of cells gets finalized. When the demand increases, number of operators required for manufacturing the component also increases proportionately. Some time it is essential to run a machine for three shifts.
In order to set a production at a particular range following points are important.
a) Cell formation for different machines.

Standard time required for a cell.

Once layout has been made no changes can be made in layout with increase in demand. Minimum walking time required between two machines in a cell, due to this standard time is reduced.

Takt Time as per customer demand = Available work time per shift / Customer demand per shift

a) Muffler Assembly Line = 27000 sec. / 42 Jobs = 624 Sec. / Job
b) Tail Pipe Assembly Line = 27000 sec. / 42 Jobs = 624 Sec. / Job
c) Front Pipe Assembly Line = 27000 sec. / 58 Jobs = 465 Sec. / Job

Table 2.*Utilization of existing assembly lines*

Utilization of MUFFLER ASSY					
Station No.	Cycle Time in Min.	Available Time (Sec.)	Jobs/Shift/Operator	Required Target /Shift	% Utilization
OPN NO : 20	1.96	27000	229	120	52
OPN NO : 30	1.13	27000	398	120	31
OPN NO : 50	1.63	27000	276	120	44
OPN NO : 60	1.73	27000	260	120	47
OPN NO : 70	2.08	27000	216	120	56
OPN NO : 80	2.53	27000	177	120	68
OPN NO : 90	3.26	27000	138	120	87
THROUGHPUT TIME	14.32				
Utilization of FRONT PIPE ASSY					
Station No.	Cycle Time in Min.	Available Time (Sec.)	Jobs/Shift/Operator	Required Target /Shift	% Utilization
OPN NO : 25	0.85	27000	1377	140	11
OPN NO : 35	0.69	27000	652	140	22
OPN NO : 45	0.35	27000	1285	140	11
OPN NO : 55	2.31	27000	194	140	73
OPN NO : 65	2.66	27000	169	140	83
OPN NO : 75	1.06	27000	424	140	34
OPN NO : 77	2.41	27000	186	140	76
OPN NO : 78	0.85	27000	529	140	27
OPN NO : 79	2.64	27000	170	140	83
OPN NO : 110	1.18	27000	381	140	37
THROUGHPUT TIME	15				
Utilization of TAIL PIPE ASSY					
Station No.	Cycle Time in Min.	Available Time (Sec.)	Jobs/Shift/Operator	Required Target /Shift	% Utilization
OPN NO : 20	2.61	27000	172	140	82
OPN NO : 30	1.74	27000	258	140	55
OPN NO : 40	1.31	27000	343	140	41
OPN NO : 50	1.13	27000	398	140	36
OPN NO : 60	1.2	27000	375	140	38
OPN NO : 70	0.65	27000	692	140	21
OPN NO : 80	1.74	27000	258	140	55
THROUGHPUT TIME	10.38				

Productivity:

a) Muffler Assembly Line = 140 Jobs / Shift
b) Tail Pipe Assembly Line = 140 Jobs / Shift
c) Front Pipe Assembly Line = 120 Jobs / Shift

No. of operators: Refer Fig.3-5

a) Muffler Assembly Line = 06
b) Tail Pipe Assembly Line = 04
c) Front Pipe Assembly Line = 09

V. CELLULAR LAYOUT

After cell information, it is essential machines at proper location. Due to change in demand it directly affects a layout if proper layout is not present. Generally, shape of layout is 'U' shape, also cell having triangular, rectangular, trapezoidal etc. is used. Cell operation is based on elemental operation time details. One operator can operate one cell,

so that minimum operator required as compared to existing layout.

a) Manpower utilization for cellular layout-

In cellular layout, during auto cycle, operator can work on next machine so that manpower utilization increases.

Target = Available Time/Basic Time

Manpower utilization = Required Target/Target achieved

From "Table 3" Average % utilization for

a) Muffler Assembly Line = 95%

b) Tail Pipe Assembly Line = 93%

c) Front Pipe Assembly Line = 87%

Average % utilization for Exhaust system assembly line = 92%

If 2% time reduces due to machine break down, industrial department conducts study, machine trial.

Average % utilization for Exhaust system assembly line = 90%

In cellular layout shift wise production is planned for processing of a component on a different machine, which is given in Fig.2. Also proposed cellular layout and material flow in cellular layout is shown in Fig.2.

VI. COST ANALYSIS

a) Cost saving for trolleys

In Exhaust system assembly line, pallets are required for storing of a component after processing on each machine. Due to cellular layout pallets are minimizing as compare to existing layout.

Total cost saving for trolleys in Exhaust system assembly line = Rs. 5, 40,000.

b) Cost of handling for raw material and finish component

Trolleys are used for handling of raw material from store to exhaust system assembly line. Handling of raw material and finish components for Tail Pipe Assembly Line takes place in two trips, Muffler Assembly Line in two trips and Front Pipe Assembly Line in ten trips in a day with the help of trolley.

c) Material handling in existing layout

Distance and time required for transferring the raw material from store to exhaust system assembly line:

Muffler Assembly Line = 200 meters, 7 min. /trip (14 min.)

Tail Pipe Assembly Line = 232 meters, 8 min. /trip (16 min.)

Front Pipe Assembly Line= 215 meters, 7.5 min. /trip (75 min.)

Table 3.Manpower Utilization

Muffler Assembly Line					
OPR.	OPN. NO	B.T/CELL (MIN)	TARGET (Job/ Shift)	REQUIRED TARGET	%UTILIZATION
1	20,30	3.09	115	120	96
2	50,60	3.36	133	120	100
3	70,80	4.61	98	120	82
4	90	3.26	138	120	100
Tail Pipe Assembly Line					
OPR.	OPN. NO	B.T/CELL (MIN)	TARGET (Job/ Shift)	REQUIRED TARGET	%UTILIZATION
1	20,70	3.26	138	140	98
2	30,80	3.48	129	140	92
3	40,50,60	3.64	123	140	87
Front Pipe Assembly Line					
OPR.	OPN. NO	B.T/CELL (MIN)	TARGET (Job/ Shift)	REQUIRED TARGET	%UTILIZATION
1	25,35,45,55	4.2	107	140	77
2	65.75	3.72	120	140	86
3	77,78	3.26	138	140	99
4	79,110	3.82	117	140	84

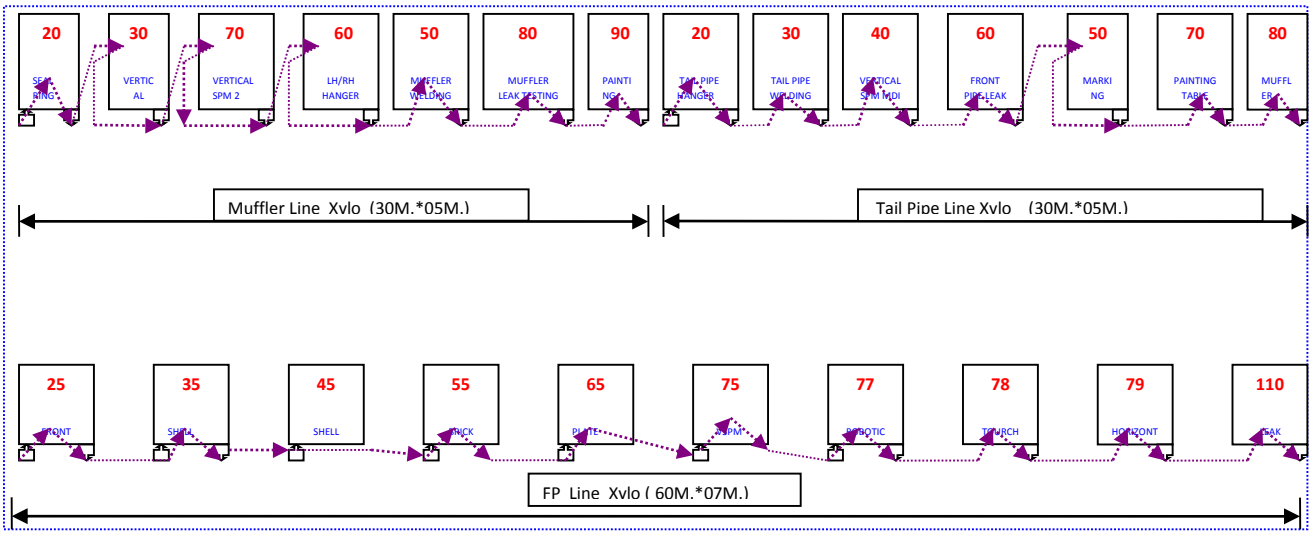

***Figure1. E**xisting Layout*

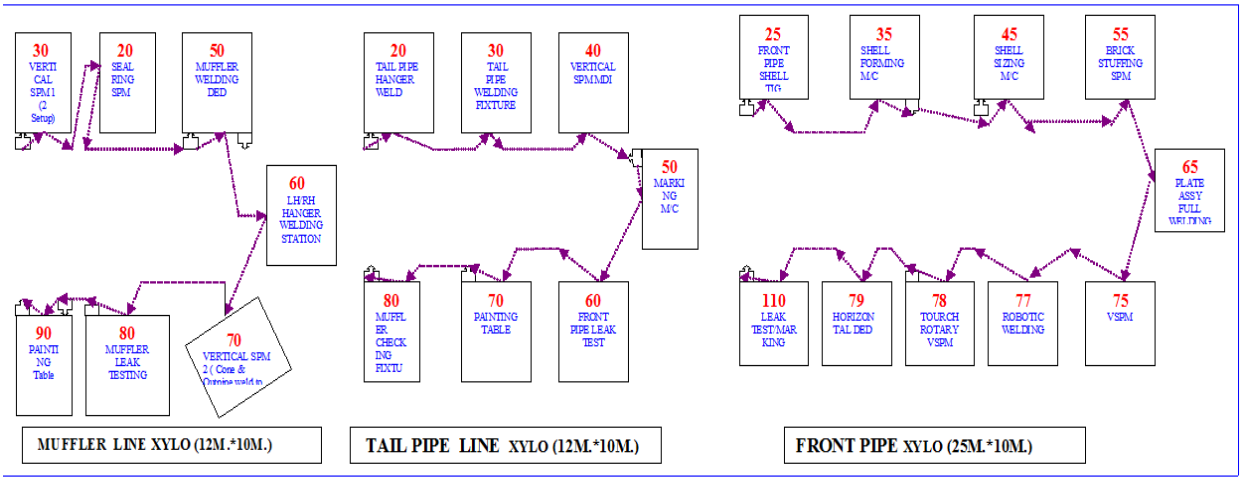

***Figure 2. P**roposed Layout*

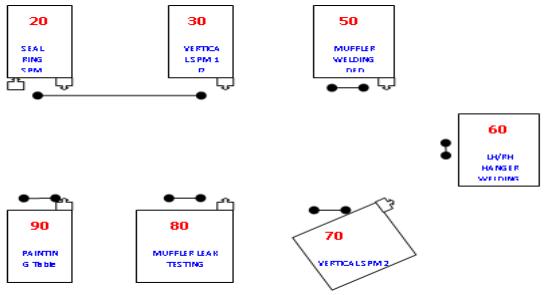

***Figure 3.O**perators for Muffler Line*

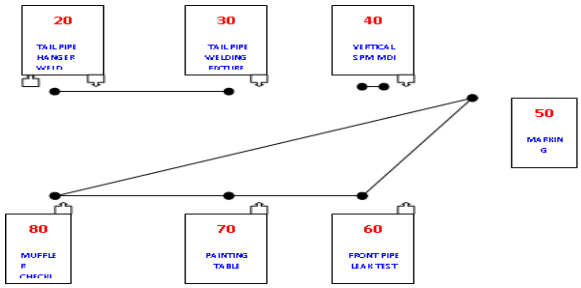

***Figure 4.O**perator for TP line*

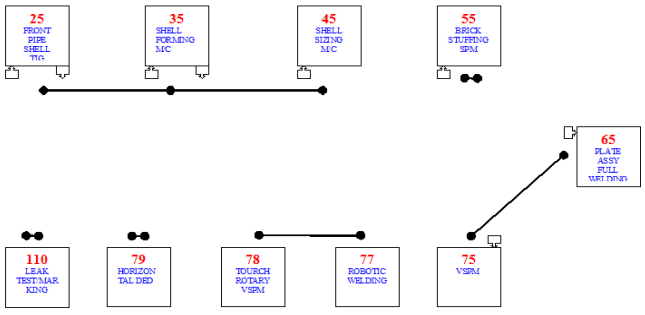

***Figure 5.O**perators for FP Line*

Distance and time required for transferring finished component from Exhaust system assembly line to pre delivery inspection station:

Muffler Assembly Line = 100 meters, 5 min. /trip (10 min.)
Tail Pipe Assembly Line = 128 meters, 6 min. /trip (12 min.)
Front Pipe Assembly Line= 138 meters, 6.25 min. /trip (62.5 min.)
Total time required for transferring the raw material from stores to assembly line is:
= (16 + 14 + 75 + 12 + 10 + 62.5) = 190 min. /day.
For 25 days (month) = 4750 min. /month
Number of operator required for handling of lift truck = 4750 x 1.17 / 480 = 11.578 = 12 operators / month
Cost of operator for handling = 12 x 20000/25 = Rs. 9,600 /month.

-Material handling in cellular layout

Distance and time required for transferring the raw material from store to Exhaust system assembly line:
Muffler Assembly Line = 200 meters, 7 min. /trip (14 min.)
Tail Pipe Assembly Line = 214 meters, 7.5 min. /trip (15 min.)
Front Pipe Assembly Line= 236 meters, 8.5 min. /trip (85 min.)

Distance and time required for transferring the finish component from Exhaust system assembly line to pre delivery inspection station:
Muffler Assembly Line = 70 meters, 4 min. /trip (8 min.)
Tail Pipe Assembly Line = 84 meters, 4.5 min. /trip (9 min.)
Front Pipe Assembly Line= 97 meters, 5.5 min. /trip (55 min.)
Total time required for transferring the raw material from stores to assembly line:
= (15+ 14 + 85 + 8 + 9 + 5) = 186 min. /day.
For 25 days (month) = 4650 min. /month

Number of operator required for handling of lift truck = 4650 x 1.17/480 = 11.332 operator/month= 12 operator / month
Cost of operator for handling = 12 x 20000/25 = Rs. 9,600 /month.
Cost for existing and cellular layout will remains nearly same but time saving due to cellular layout is (4750 – 4650) = 100 min. / month = 4 min. / day

-Floor Space and cost

Cost of land for each square feet is assumed as Rs. 1000.
Area of Existing layout = (62 meters X 13 meters) = 806 meters = 2644 sq. ft.
Cost of Existing layout = 2644 X 1000 = Rs. 26, 44,000
Area of Proposed layout = (53 meters X 10 meters) = 530 meters = 1738 sq. ft.
Cost of Proposed layout = 1738 X 1000 = Rs. 17, 38,000
Cost Saving for floor space = Rs. 26, 44,000 - Rs. 17, 38,000 = Rs. 9, 06,000.

-Cost of Reinstallation

Approximate Total cost of reinstallation is about Rs. 20, 00,000.
(Considering M/C location change cost, Conveyor cost, Production line stop cost while implementation)
Cost saving due to reduction of Trolleys is Rs. 5, 40, 000.
Cost Saving for floor space = Rs. 9, 06,000.

-Payback Period Calculation

The net revenue in a given year is referred to as the net annual cash flow (NACF).
If the revenue exceeds costs for the year, the NACF is positive otherwise it is negative.
The payback period is defined as follows:
N = IC/NACF
Where, IC is the initial cost of the investment,
N is the payback period (expressed in years).
Nominal Interest Rate (r) = 18%
Effective Interest Rate (i) = (1+r/m) m-1
Where, m = number of compounding periods per year
Effective Interest Rate (r) = (1 + 0.18 / 12) 12-1= 19.56 %
Total Interest = Rs. 2, 93,400
Initial Cost (IC) = Rs. 20, 00,000 + Rs. 2, 93.400= Rs. 22, 93,400
Cost saving due to reduction of Trolleys is Rs. 5, 40,000
Cost Saving for floor space = Rs. 9, 06,000
Net Annual Cash Flow (NACF) = Rs. 5, 40,000 + Rs. 9, 06,000 = Rs.14, 46,000
Payback Period, N = IC / NACF= 22, 93,400/ 14, 46,000 = 1.6 years
Therefore, payback period is one year and 06 months, when manufacturing a component based on cellular layout.

VII. RESULTS AND DISCUSSION

From the study and analysis it is found that:

1. In existing layout space required for Exhaust system assembly line was 60mtr. X 12 meter (i.e. 720 square meters.) Due to cellular, it is reduced to 49 meter X 10 meter (i.e. 490 square meters) Therefore, space saving is 130 square meters.
2. Cost of reinstallation of the layout is about Rs. 20, 00,000, from payback period calculation the payback period for reinstallation cost is equal to six months.
3. Trolleys are required for storing of a component after processing on each machine. Due to cellular layout pallets are minimizing as compare to existing layout. In existing layout, pallets required for Muffler Assembly Line, Tail Pipe Assembly Line and Front Pipe Assembly Line are 08 for each. Due to Cellular layout, it is reduced to 05, 04 and 05 respectively. Considering Cost/Pallet = Rs. 30000 (Total 05 Pallets reduced). Total cost saving for pallets in Cellular Layout = Rs. 1, 50, 000.

ACKNOWLEDGMENT

The authors gratefully acknowledge the contributions of Sharda Motors Industries Ltd., Nashik for carrying out the research works.

REFERENCES

[1]. Agarwal A., "Partitioning bottleneck work centre for cellular manufacturing: An integrated performance and cost model", International Journal of Production Economics, 111(2): 635 – 647, 2008.
[2]. Mohammad M.P., Mohammad S. M. & Ebrahim T., "A robust optimisation model for generalised cell formation problem considering machine layout and supplier selection", International Journal of Computer Integrated Manufacturing, 27(8):772-786, 2014.
[3]. Bhangale J.H. and Mahalle A.M., "Performance Issues of CMS in Automobile Industries using Computer Simulation", International Journal of Computer Applications, 52(5):31-35, 2012.
[4]. Bharamgude P.S., & Telsang M.T., "Design, Analysis and Performance Simulation of Cellular Manufacturing System - A Case Study", Proceedings of 8th IRF International Conference, Pune, 79-82, 2014.
[5]. Arora P. K. et al., "Cell Formation Techniques – A Study", International Journal of Engineering Science and Technology, 3:1178-1182, 2011.
[6]. Ghosh T. & Dan P. K., "Modelling of Optimal Design of Manufacturing Cell Layout Considering Material Flow and Closeness Rating Factors", Proceedings of 4th International & 25th AIMTDR Conference, 2012.
[7]. Paul P.,Koshy J & Abraham B.C., "Conversion of Regular Assembly Line into Cellular Manufacturing Layout", International Journal of Engineering and Innovative Technology,2(7):250-255, 2013.
[8]. Bhangale J.H. and Mahalle A.M., "Studies of Productivity Improvement in Indian Automobile Industries Plant Layout", International Journal of Advanced Technology in Engineering and Science, 03(01):254-263, 2015.
[9]. Darla S.P. et al., "Optimization of Inter Cellular Movement of Parts in Cellular Manufacturing System Using Genetic Algorithm", Research Journal of Applied Sciences, Engineering and Technology, 7(1): 165-168, 2014.
[10]. Selim H., Askin R. & Vakharia A., "Cell Formation in Group Technology: Review, Evaluation and Directions for Future Research". Computers and Industrial Engineering, 34(1):3-20, 1998.
[11]. Suleyman S., "Using advanced technology in automotive sector and relationship of technology management", Academic Journals - Scientific Research and Essay, 5 (1): 001-008, 2010.
[12]. Danny J. J., "A Framework for Reducing Manufacturing Throughput Time", Journal of Manufacturing Systems, 22(4):283-298, 2003.
[13]. Bhangale J.H. and Mahalle A.M., "Parametric Studies in Automobile Manufacturing Industry using Cell Focused Plant Layout Simulation Approach", European Scientific Journal, 9(9):261-275, 2013.