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Modification in layout of the plant of Heavy Industry: An effort towards Productivity Improvement

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Abstract : The study has been conducted in a heavy job type small scale industry located at Meerut road Ghaziabad, Uttar Pradesh, which manufactures complete part of the Sugar mill. While manufacturing the parts, there are two modes of material handling. One is with the help of hand trolley while other is with the help of power (Diesel) trolley. The Existing Plant Layout of the Company has been designed in such a way that there is no optimum utilization of the resources. Travel Chart Technique is applied to minimize wastes of time, manpower and money and to generate higher profits for the same work from the same resources .Two improved layout have been developed by considering the material handling costs , First Improved layout is developed by making only one change [Raw Material storage Section (A) and Machine Shop –2 (C) are interchanged there positions] to existing layout , This reduces the materials handling costs by Rs.528.84 per day for hand trolley and Rs.248.4 per day for diesel trolley, Second Improvement layout is developed by making one more change [Assembly section (F) and Machine shop- 3 (E) are interchanged there positions] to the first Improved layout . It reduces the material handling costs by Rs. 711.67 per day for hand trolley and Rs. 146.66 per day for diesel trolley.

Keywords : Productivity improvement, Heavy industry,sugar mill, small scale industry, manufacturing

Introduction

With rapid increasing of demand in production, industrial factories need to increase their potentials in production and effectiveness to compete against their market rivals. 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), standard time, plant layout to solve the problems concerning productivity. For example, a case studies from the lamp industry [1]. The found problem was that the staff did not work in orderly manner, resulting in confusion and no standard time nor facilitating tool. The staff spent too much time on work. The way to solve these problems was to improve the steps in working and the area where they worked through observation and fieldwork as well as proposing tools to facilitate the work to set balance and find the standardized time. In additional Yookkasemwong *et al*. [2] studied the production process for Cable box to form metal. The problem was that the work could not be finished within 8 hours. The problem was then studied from data collection, the actual time, load, improper plant layout, and the duration of the process. The impact of improper plant layout on the manufacturing process for valve and metal parts production has been studied. The plant layout was changed to comply with the international standards through Systematic Layout Planning method [3]. Sucharitkul *et al*. studied the possibility of plant layout and installing aluminum foundry [4]. As for the layout of plant, it was done in accordance with the steps in systematic plant layout design. Yujie *et al*. studied the general plane of long yards using systematic layout planning method which the best layout showed the good workflow and practical significance [5].

The Company under consideration is manufacturing complete sugar mill parts and assembled together inside the industry in all 7 (A,B,C,D,E,F& G) Departments, located at various places inside industry .It has69,300sq.meters (315 *220) of area and works for 3 shifts in a 24 hour day with an average of 300 worker per shift . The material handling from one department to another is by means of hand trolley and diesel trolley .

Improvement of plant layout results in decrease in material handling
cost and increase in productivity. Thus an attempt has been made in this work to improve the existing layout of the plant by making minor changes with respect to the position of the department/sections. The travel chart technique is used for analysis of material handling cost between the department/sections.

Summary of Different Shops

Raw Material Storage(A) :-Raw material storage is placed in a plant for storage of raw material for all departments;

First arrive all raw material in industry in a raw material storage section after that depending upon requirements of further machining raw material move from storage to other section.

Machine Shop 1 (B) :-In Machine shop1 there are 3 Horizontal Boring Machine with automatic Movements of digital control in X- Y – Z direction ; In this shop casting of A-mill frame, Top Cap , hydraulic coupling , Muff coupling are machining and same time base plate for foundation of mill also machined

Machine Shop2 (C) :- Machine shop 2 comprises of small sizes of lathe machine and one vertical boring Machine . This shop is used for machining of clamping devices , small parts like bush , studs and other small parts as per requirements by different shops.

Machine Shop3 (E): - Machine shop-3 comprises of large lathe M/c , Drill Machine , Drill machine and one small size horizontal boring machine . In this shop turning of shaft is the main work and same time bearing housingbore is also machined by horizontal boring machine.

Machine Shop4 (D): Machine shop 4 comprises of slotter machine , Shaper machine and drilling machine . In this shop main work is key way in a gear and key way in a shaft , drill in a different parts as per requirement by product. **2.7**

Assembly Section (F) : - Assembly section is a important section for an industry . In assembly section all the material arrive after Machine in each section , finally mill assembled in this section

Fabrication Section (G) :- Fabrication department play a very important role in industry mainly for sugar industry . In this section different type of welding Machine and gas cutter is used.

PRINCIPLES of Plant Layout

1.Principle of Integration
2. Minimum Movements of Material Handling (Principle of minimum distance)
3. Principle of Cubic space utilization
4. Principle of flow
5. Principle of Maximum flexibility
6. Principle of Safety, Security and Satisfaction
7. Principle of Minimum handling

Factors Influencing Plant Layout

1. Type of Production – Engineering Industry, Process Industry.
2. Production System – Job Shop, batch production, mass production.
3. Scale of production.
4. Availability of the total area.
5. Arrangement of material handling system.
6. Type of building – Single storey or Multi storey.
7. Future Expansion Plan.
8. Type of Production facilities – dedicated or general purpose.

Symptoms of Bad plant Layout:

1. Long material flow lines and backtracking (rehandling).
2. Poor utilization of space.
3. Congestion for movement of materials and men.
4. Large amount of work in process.
5. Long production cycles.
6. Excessive handling of materials.
7. More frequent of accidents.
8. Difficult to supervise and control.
9. Spoilage of products during handling.
10. Production line bottlenecks.

Plant Layout procedure

1. Collect the detailed information about the product, process, etc., and record the data systematically.
2. Analyse the data using various techniques of analysis.
3. Select the general flow pattern for the materials.
4. Design the individual work stations.
5. Assemble the individual layout into total layout in accordance with the general flow pattern and the building facilities.
6. Coordinate the plan with plan for handling materials.
7. Complete the plant layout.
8. Convent the plant layout into floor plans that is to be used by the plant engineer for installation of equipment.

Tools and Techniques of Plant Layout

The quantity and quality of the data on various factors is required to develop a good layout. The data is to be collected regarding the various processes, sequence of operations, material flow frequency of travel, space requirements, activities and there relationships. The following tools and techniques are used to analyses the data.

1. Process Chart - (Operation process charts, flow process charts).
2. Travel Chart
3. Diagrams – (Flow Diagrams and String Diagrams).
4. REL – (Relationship chart).
5. Templates
6. Scaled Models

Plant Layout Analysis:

The most important criterion for the analysis and selection of a plant layout is the material handling cost. The basic tool that is primarily used to analyze the material handling costs in process layout is the travel chart. Depending on the existing plant layout, an analyst may follow a procedure given follow:

Step 1. Summarize the interdepartmental moves of existing layout in a square grid (from interdepartmental flow diagram).

Step2. Simplify the grid (or from to chart) by combining moves and countermoves between any two departments.

Step3. Prepare the Material handling cost matrix of the existing layout by multiplying the unit material handling cost by the number of moves between various departments.

Step4: Calculate the total material handling cost of the existing layout.

Step5: Search the possible departmental changes that will reduce the number of moves and consequently calculate the total material handling cost.

Problem Identification:

The plant is to produce complete Sugar Mill Parts by using the same manufacturing facilities arranged in 7 departments, viz., Raw Material storage Section (A), Machine Shop-1 (B), Machine Shop-2 (C) Machine Shop-4 (D) Machine Shop-3 (E), Assembly Section (F) and Fabrication department (G).

Hand trolley and Diesel Trolley used for handling of raw material and other processed material between different departments.

The distance between various departments are as follows (Table I):

Table I: Distance between various departments

Department (From – To)	Distance (meter)
2 A-B	100
3 A-C	112
A-E	98
A-F	182
A-G	251
B-C	100.2
B-D	151.2
B-F	221.5
B-G	192
C-F	184.2
D-F	120
E-F	65
G-F	95

The salaries/month of hand trolley operator and diesel trolley operator are:
Hand trolley operator - Rs.4000/month
Diesel trolley operator – Rs.6000/month
Number of hand trolley operator –7
Number of Diesel trolley operator-3

Assumption and constraints

The assumptions and constraints used in the analysis are:

1. The position of generator complex , administration block and General Manager room are not changed for improvement because the are not involved in any material transfer.
2. The position of casting which is situated around 30kM from the industry is not changed.
3. Depreciation costs of hand trolleys and diesel trolleys are not considered while calculating the unit material handling costs.
4. Fixed costs of loading and unloading are not considered, as they cannot be reduced.

Calculation of Material Handling costs

1. Existing Plant Layout

(A) For Hand Trolley (Table 5.9)

Total distance travel by hand trolley in between the various departments per day = Σ MiDi
= 26046 m/day
= 26046/3per shift per day (3 Shift in one day)
=8682m per shift per day

Average Material handling Cost /meter =
(Wages of worker/shift)* / average distance travel per shift per day
=(Number of worker* salary of one worker per day)/Average distance travel per day

=(7*Rs.4000/30)/8682
=**Rs.0.10750/meter**

Total Material handling cost/day for hand Trolley(Including all three shift) = Total distance in meter * average material handling cost per meter
= 26046*Rs.0.1075
=Rs. 2800 per day

Table II: Material handling cost for hand trolley between various departments (For Existing Layout)

SI.No.	Movement	Material handling cost/day =Avg. cost/m* distance/day	Material handling cost in descending order
1	**4** A-B	Rs.0.1075*900= Rs.96.75	2
2	**5** A-C	Rs.0.1075*3360= Rs.361.20	10
3	A-E	Rs.0.1075*980= Rs.105.35	3
4	A-F	Rs.0.1075*3640= Rs.391.30	11
5	A-G	Rs.0.1075*7530= Rs.809.475	12
6	B-C	Rs.0.1075*1202.4= Rs.129.25	6
7	B-D	Rs.0.1075*1209.6= Rs.130.03	7
8	B-F	-	-
9	B-G	Rs.0.1075*1536= Rs.165.12	8
10	C-F	Rs.0.1075*2763= Rs.297.02	9
11	D-F	Rs.0.1075*1200= Rs.129	5
12	E-F	Rs.0.1075*585= Rs.62.88	1
13	G-F	Rs.0.1075*1140= Rs.122.55	4

Total Material handling cost/day for hand Trolley
=Rs. 2800 per day

Improved Layout –I(For hand trolley)

Changes :-In first improvement of layout the position of Machine shop –1(C) and Raw Material storage Section (A) are interchanged and other department at the same position as in existing layout.. Number of movement between different department is not changed i.e. Move grid is same as existing plant layout.

Total distance travel by hand trolley in between the various departments per day = Σ MiDi
= 21127 m/day
Average Material handling Cost /meter = Rs.0.10750/meter
Total Material handling costs/day = Rs.0.10750/meter*21127 m/day
= Rs. 2271.15 /day

Table III Material handling cost

SI.No.	Movement	Material handling cost/day =Avg. cost/m* distance/day	Material handling cost in descending order
1	**6** A-B	Rs.0.10750*901.8=Rs.96.94	2
2	**7** A-C	Rs.0.10750*3360=Rs.361.2	10
3	A-E	Rs.0.10750*1025=Rs.110.18	3
4	A-F	Rs.0.10750*3684=Rs.396.03	11
5	A-G	Rs.0.10750*2556=Rs.274.77	8
6	B-C	Rs.0.10750*1200=Rs.129	5
7	B-D	Rs.0.10750*1209.6=Rs.130.03	6
8	B-F	-	-
9	B-G	Rs.0.10750*1536=Rs.165.12	7
10	C-F	Rs.0.10750*2730=Rs.293.47	9
11	D-F	Rs.0.10750*1200=Rs.129	5
12	E-F	Rs.0.10750*585=Rs.62.88	1
13	G-F	Rs.0.10750*1140=Rs.122.55	4

Total Material handling cost/day for hand Trolley
=Rs. 2271.15 per day

II- Improved Layout

Changes:- In first improvement of layout the position of Machine Shop-3 (E), Assembly Section (F) are interchanged and other department at the same position as in I-improved layout.. Number of movement between different department is not changed i.e. Move grid is same as existing plant layout.

Total distance travel by hand trolley in between the various departments per day = Σ MiDi
= 19426.4 m/day
Average Material handling Cost /meter = Rs.0.10750/meter
Total Material handling costs/day = Rs.0.10750/meter*19426.4m/day
= Rs. 2088.33 /day

Table IV Material handling cost

SI.No.	Movement	Material handling cost/day =Avg. cost/m* distance/day	Material handling cost in descending order
1	**8** A-B	Rs.0.10750*901.8=Rs.96.64	2
2	**9** A-C	Rs.0.10750*3360=Rs.361.20	12
3	A-E	Rs.0.10750*1842=Rs.198.01	9
4	A-F	Rs.0.10750*2050=Rs.220.37	10
5	A-G	Rs.0.10750*2556=Rs.274.77	11
6	B-C	Rs.0.10750*1200=Rs.129	4
7	B-D	Rs.0.10750*1209.6=Rs.130.03	5
8	B-F	-	-
9	B-G	Rs.0.10750*1536=Rs.165.12	7
10	C-F	Rs.0.10750*1470=Rs.158.02	6
11	D-F	Rs.0.10750*1012=Rs.108.79	3
12	E-F	Rs.0.10750*585=Rs.62.88	1
13	G-F	Rs.0.10750*1704=Rs.183.18	8

Total Material handling cost/day for hand Trolley
=Rs. 2088.33 per day

(B) Existing Plant Layout(For Diesel Trolley)

Total distance travel by diesel trolley in between the various departments per day = Σ MiDi
= 4596.3 m/day
= 4596.3 /3per shift per day (3 Shift in one day)
=1532.1m per shift per day
Average Material handling Cost /meter =
(Wages of worker /shift)* / average distance travel per shift per day
=(Number of worker* salary of one worker per day)/Average distance travel per day
=(3*Rs.6000/30)/1532.1
=**Rs.0. 39162/meter**
Total Material handling cost/day for Diesel Trolley(Including all three shift) = Total distance in meter * average material handling cost per meter
= 4596.3*Rs.0. 39162
=Rs. 1800 per day

Table V Material handling cost

SI.No.	Movement	Material handling cost/day =Avg. cost/m* distance/day	Material handling cost in descending order
1	**10** A-B	Rs.0.3916*300=Rs.117.48	2
2	**11** A-C	-	-
3	A-E	Rs.0.3916*392=Rs.153.50	4
4	A-F	-	-
5	A-G	Rs.0.3916*1004=Rs.393.16	9
6	B-C	-	-
7	B-D	Rs.0.3916*604.8=Rs.236.83	7
8	B-F	Rs.0.3916*664.5=Rs.260.21	8
9	B-G	Rs.0.3916*576=Rs.225.56	6
10	C-F	-	-
11	D-F	Rs.0.3916*480=Rs.187.96	5
12	E-F	Rs.0.3916*195=Rs.76.36	1
13	G-F	Rs.0.3916*380=Rs.148.80	3

Total Material handling cost/day for Diesel Trolley
=Rs. 1800 per day

Improved Layout –I(For diesel trolley)

Changes :-In first improvement of layout the position of Machine shop –1(C) and Raw Material storage Section (A) are interchanged and other department at the same position as in existing layout.. Number of movement between different department is not changed i.e. Move grid is same as existing plant layout.

Total distance travel by diesel trolley in between the various departments per day = Σ MiDi
= 3962.2 m/day

Average Material handling Cost /meter ==Rs.0. 39162/meter

Total Material handling costs/day = Rs.0. 39162/meter*3962.2 m/day
= Rs.1551.6 /day

Table VI

SI.No.	Movement	Material handling cost/day =Avg. cost/m* distance/day	Material handling cost in descending order
1	**12** A-B	Rs.0. 3916*300.6=Rs.117.71	2
2	**13** A-C	-	-
3	A-E	Rs.0. 3916*410=Rs.160.55	5
4	A-F	-	-
5	A-G	Rs.0. 3916*340.8=Rs.133.45	3
6	B-C	-	-
7	B-D	Rs.0. 3916*604.8=Rs.236.83	8
8	B-F	Rs.0. 3916*675=Rs.264.33	9
9	B-G	Rs.0. 3916*576=Rs.225.56	7
10	C-F	-	-
11	D-F	Rs.0. 3916*480=Rs.187.96	6
12	E-F	Rs.0. 3916*195=Rs.76.36	1
13	G-F	Rs.0. 3916*380=Rs.148.80	4

Total Material handling cost/day for diesel Trolley
=Rs. Rs.1551.6 per day

II- Improved Layout

Changes:- In first improvement of layout the position of Machine Shop-3 (E), Assembly Section (F) are interchanged and other department at the same position as in I-improved layout.. Number of movement between different department is not changed i.e. Move grid is same as existing plant layout.

Total distance travel by diesel trolley in between the various departments per day = Σ MiDi
= 4221.8m/day
Average Material handling Cost /meter ==Rs.0. 39162/meter
Total Material handling costs/day = Rs.0. 39162/meter*4221.8 m/day
= Rs.1653.34 /day

Table VII

SI.No.	Movement	Material handling cost/day =Avg. cost/m* distance/day	Material handling cost in descending order
1	**14** A-B	Rs.0. 3916*300.6=Rs.117.71	2
2	**15** A-C	-	-
3	A-E	Rs.0. 3916*736.8=Rs.288.53	9
4	A-F	-	-
5	A-G	Rs.0. 3916*340.8=Rs.133.45	3
6	B-C	-	-
7	B-D	Rs.0. 3916*604.8=Rs.236.83	8
8	B-F	Rs.0. 3916*495=Rs.193.842	5
9	B-G	Rs.0. 3916*576=Rs.225.56	7
10	C-F	-	-
11	D-F	Rs.0. 3916*404.8=Rs.158.52	4
12	E-F	Rs.0. 3916*195=Rs.76.36	1
13	G-F	Rs.0. 3916*568=Rs.222.42	6

Total Material handling cost/day for diesel Trolley
=Rs. 1653.34 per day

Summary of the analysis:-

Table VIII

Layout	Changes made	Total Material Handling Costs (Rs/day)	
		For Hand Trolley	For Diesel Trolley
Existing Layout	-	2800	1800
I- Improved Layout	Position of Machine shop –1(C) and Raw Material storage Section (A) are interchanged	2271.15	1551.6
II- Improved Layout	Position of Machine Shop-3 (E), Assembly Section (F) are interchanged	2088.33	1653.34

Conclusions

Two improved layout were developed from the existing layout by travel chart technique analysis using material handling costs as the criterion. By implementing the first improved lay out, the material handling cost can be reduced by Rs.528.84per day for hand trolley and Rs. 248.4 per day for diesel trolley, and by implementing the 2nd improved layout the material handling cost can be reduced by Rs711.68 per day for hand trolley and Rs. 146.66per day for diesel trolley.

On the basis of minimum number of changes, the improved layout -1, will be considered as the optimum layout; and on the basis of cost reduction, the improved layout-2 can be considered as optimum layout .It is to be observed that by following any of the improved layouts the material handling cost of diesel trolley reduced by the same amount.

Therefore the company can adopt any of the improved layouts suitable to its practical operating conditions. 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 the productivity will be increased.

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