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Research Article

Improving Productivity in a Paint Industry using Industrial Engineering Tools and Techniques

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Abstract

Effective planning and designing of manufacturing processes and equipment helps in achieving optimum productivity through maximum utilization of the resources available leading to least possible industrial wastage thus resulting in low production cost. The aim of this paper is to study the implementation of industrial engineering tools in a paint industry. This study started with observing the standard operation procedures and understanding the existing process flow. At the same time, observations at the production line were made to identify problems and areas of possible improvements. Time study, method study and layout study techniques formed an integrated platform to help identify and rectify the time lost in unnecessary movements of labor and tools which resulted in long machine idle time. The packaging method used was conventional and time consuming which was simplified. There were suggestions proposed how redesigning of the process flow and efficient material handling could save idle time for machines, how replacing the old packaging method with use of zip ties would require less manpower and could help mitigate the non-value added activities, thereby resulting in improved productivity of the industry.

Keywords: *Work Study, Method Study, Time Study, Layout Study, Productivity, Material Handling Improvement.*

1. Introduction

International Labor Organization defines work study as the technique of method study and work measurement employed to ensure the best possible use of human and material resources in carrying out a specified activity. It is also a management service based on method study and work measurement used in examination of human work leading to investigation of all the resources that effect efficiency and economy of situation to affect improvement. Further ILO states that work study is to minimize cost either by designing the work for high productivity or by improving productivity in existing work through improvements in current methods by reducing ineffective and wasted time. Therefore, it can be said that it is a direct means of raising the productivity. It is most frequently used to increase the amount of production from a given quantity of resources with little or no further capital investment and hence work study has direct relation to productivity improvement.

Lean manufacturing is a production practice that considers the expenditure of resources from any goal other than the value for the end customer to be wasteful, and thus a target for elimination (Shashikant Shinde *et al*, 2014). Working from perspective of the customer who consumes a product or a service Value is defined as any action or process that a customer would be willing to pay for. SMED is one of the techniques from lean manufacturing. Set up time reduction is done in this case study. Plant efficiency can be improved due to Systematic Layout Planning (Varsha Karandikar *et al*, 2014). By improving the layout it was shown that the material flow lead time can be brought down. Similar concept is used in this case study.

This project was taken up in the Company X, mainly into manufacturing products such as acrylic distemper, water based primer and water based putty, situated in Parvati Industrial Estate, Pune, India. Company was keen to change the flow process and adopt concepts of lean manufacturing aiming to increase production turnover in a healthy manufacturing environment.

Having observed the current manufacturing flow process it was noted that the shop floor has two identical machines in which all the three products are manufactured. Apart from the main machines there is a heavy duty platform scale, weighing machines, portable drum stirrer, manual pallet jack, floor hand truck, manual forklift, pallets, containers, drums, racks, stitching machines and the other basic industrial tools.

The main objective of this project was to achieve efficient production by comprehensive approach to minimize wastes by eliminating redundant movement of material, waiting and delays, over processing, excess worker motion and the need of rework and corrections.

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Each step of the manufacturing process was weighed against what value did it add to the whole process flow and was eliminated, combined, rearranged or simplified accordingly like unnecessary movements of operator and material. Working on improved material handling could act as catalyst in reducing the total time considerably. It also helped to provide ergonomic benefits by reducing human effort and thereby fatigue. Applying Layout study concepts, it helped in identifying unsystematic placement of materials which was shifted to new locations for better and faster accessibility.

Objectives of the Research

- To identify areas for potential productivity improvement.
- To have higher level of output through wastage reduction.

2. Methodology

To have a first-hand knowledge of the production flow and to be familiar with the activities being performed at the floor shop, the researcher went through the facility and identified each operation process involved from raw materials to finished goods, identified all the places where inventory is stored between the processes, and observed how the material flowed from one operation to another.

There are a number of techniques in Industrial Engineering which are suitable for eliminating wastes. Amongst these techniques the researcher opted for Work Study techniques which are Method Study and Work Measurement. Following the basic procedure of Method Study, the first challenge was to select the product to be studied.

2.1. Selection of Product

The manufacturing and packaging procedure for all the three products are almost identical. The characteristic which is responsible to distinguish between them is their chemical composition. Due to this selecting the job on the basis of economic, technical and human considerations was not possible. To overcome this problem the researcher used the other criteria to select the product to be studied. Amongst the three main products manufactured by the company the demand for water based putty was the highest as compared to the other products; therefore its batches were manufactured in greater number. So water based putty was selected as it would become easier for the researcher to proceed with the next step that was to collect data and the other relevant facts.

2.2. Recording the Facts

Data recording was the most crucial step as the success of the whole procedure depended entirely on the accuracy with which the facts were recorded, the basis of which would provide critical examination and the development of the improved method. Recording was done with the help of Flow Process Chart- Man Type and String diagram. But before any of these charts could be constituted it was required for the researcher to do the time study. The first step of time study involved a detailed analysis of the operation flow by direct observation. The entire process was broken down into elements. This was required to identify the non-productive activities and separate them from the productive ones. However it was not possible to segregate the process into elements at once so it took many attempts to successfully separate out all the elements. After this time taken by the operator to perform each element of the operation was measured using a stopwatch and was recorded in time study sheet (Refer to Fig.1). A total of 150 elements were identified which were done by the operator.

Time study was done for two processes.

- Batching and Mixing of the paint product
- Packaging of the paint product

Time study for the former process was done to find the time required by the operator to do the operations which involved setting up of the machine, mixing of chemicals, powders and other ingredients to prepare the product. These elements were basically operation, transport, inspection, delay, or storage. Therefore with the help of time study the total time required to prepare the machine was found out to be 25.5 minutes.

Similarly the second part was to do time study for packaging of products and the total time required to package the product was found out to be 56.2 minutes. In between an addition of 30 minutes was utilized by the machine for mixing of the constituents. Time for a total of 150 elements was recorded in the Time Study sheet (Refer to Fig.1).

15	Time Study Sheet			
16	S. No.	Elements	Distance (metres)	Time (seconds)
17	1	Walk to Rest Platform	9.70	6.00
18	2	Bring Rest Platform	3.00	3.00
19	3	Walk to sitting stool	3.00	7.00
20	4	Move away sitting stool	4.00	9.00
21	5	Walk to Powder Trolley	11.00	28.00
22	6	Bring Powder Trolley Near M/c	10.25	4.00
23	7	Walk to Forklift	1.30	3.00
24	8	Insert Forklift into the trolley	~	4.00
25	9	Walk to M/c	2.00	6.00

Fig.1- Time Study Sheet

After categorizing the elements properly as operation, transport, delay, storage and inspection elements in the flow process chart (Refer to Fig.2), the researcher found a total of 56 transport elements and 94 operation elements involved in the present method. Subsequently these elements were transformed into 53 transport elements and 84 operation elements summing up to a total of 137 elements.

Flow Process Chart									
S. No.	Repeating Elements	Sequence	Elements	Distance (metres)	Time (seconds)	○	⇨	D	□
1		1	Walk to Rest Platform	9.70	6.00				
2		2	Bring Rest Platform	3.00	3.00				
3		3	Walk to sitting stool	3.00	7.00				
4		4	Move away sitting stool	4.00	9.00				
5		5	Walk to Powder Trolley	11.00	28.00				
6		6	Bring Powder Trolley Near M/c	10.25	4.00				
7		7	Walk to Forklift	1.30	3.00				
8		i	Insert Forklift into the trolley	~	4.00				
9	v	8	Walk to M/c	2.00	6.00				

Fig.2- Flow Process Chart

2.3. Examining of Facts

All the elements which were found during the recording stage were now carefully categorized as either 'make ready' or 'do' or 'put away' activities. The objective was to have a high proportion of 'do' activities since these were the operations which would carry the product progressively towards its completion. Examining consists of two rounds of questioning techniques. The first round is the primary questioning round which is then followed by secondary questioning round. These questions were systematically asked with reference to purpose, place, sequence, person and means of the activities recorded and to nominate alternatives for them. The objective behind this was to implement the principle of 'ECRS' to get an improved method by eliminating, combining, reducing and simplifying, all the unnecessary movement.

High level Problems identified in a nut shell

- Improper Layout leading to excessive movements
- Improper placement of tools
- Non-productive activities adding no end value
- Improper Material handling
- Traditional and time consuming methods of packaging
- Traditional methods and equipment of manufacturing
- Poor ergonomics

2.4. Developing the Improved Method

This stage of method study is about establishing the most practical, economic and effective method by taking into accounts all the circumstances. Categorizing the identified problems the proposed solution are as follows.

2.4.1. Developing of Improved Layout

The way of arrangement of material and machinery define the layout in that area. A careful analysis of the flow was done before concluding to changes in the present layout since changing the layout is a costly process as it involves movement of heavy duty machineries and stoppage of production.

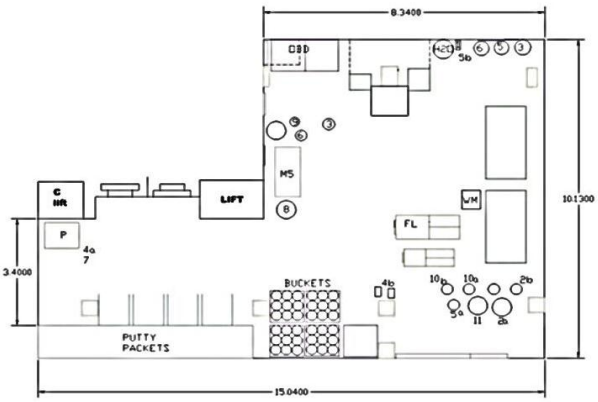

Fig.3- Original Layout

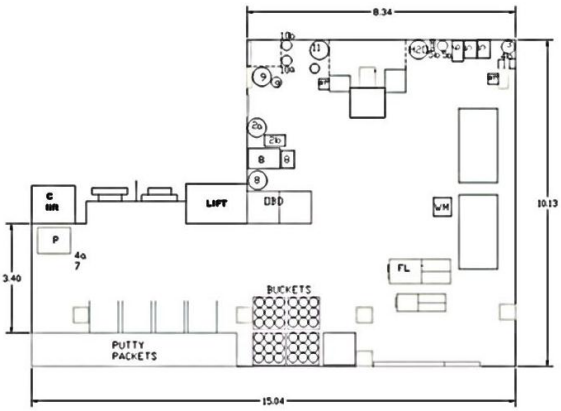

Fig.4- Proposed Layout

With the help of flow process chart (Refer to Fig.2) and string diagram (Refer to Fig.12) the researcher identified the following problems:

- All chemicals are placed far from the machine.
- Chemicals which require water are kept far away from the tap.
- The weighing machine is kept away from all preparation centers.
- There is no space for maintenance of MCB.

To reduce the worker's fatigue, improve mobility of materials, ameliorate material accessibility, increase free space and improve worker and materials's safety in accordance to convenience, the following suggestions were made (Refer to Fig. 3 & 4) :

- Rellocating the chemicals and bonds so that free space is available.
- Chemicals which require water would be kept near the tap.
- Addition of two more weighing machines for better feasibility.
- Allocation of free space for maintenance of MCB.
- Allocation of free space near containers for easier accessibility.
- Reallocation of raw materials to minimize the intrusion in the other machine set up process.
- Reallocation of packaged good near the lift area for easier accessibility.

2.4.2. Improvement in Material handling

Movement and handling of materials from one point to another in the course of processing involves significant time and effort. Although it is costly and adds no end value to the product, it cannot be eliminated completely but can be reduced substantially if appropriate methods and equipments at lowest possible cost are implemented with regard to safety. To eliminate supererogatory worker's motion and redundant movement of material the following changes the researcher proposed:

I. Overhead wiring of Manual forklift

In the present condition (Refer to Fig.5) the wiring of the manual forklift lies on the floor in a haphazard manner. Due to this the probability of the operator's feet entangling with the wire increases also restricting the motion of the manual forklift. To overcome this problem the researcher proposed overhead wiring (Refer to Fig.6) with an air tool stand including a spiral hose.

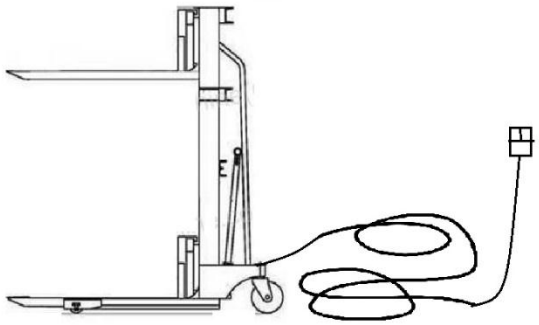

Fig.5- Present Arrangement

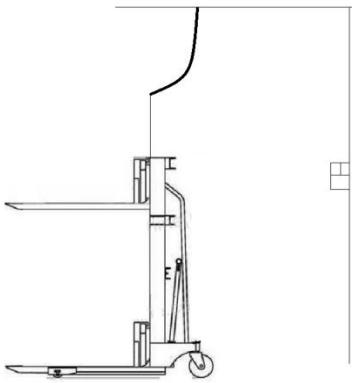

Fig.6- Proposed Arrangement

Benefits of the proposed idea area as follows:

- No obstructions in the movement of manual forklift
- Less chances of wire damage which leads to less chances of electrocution
- No restrictions in the movement of powder trolley
- Better handling techniques of manual forklift i.e., straight motion rather than radial motion

II. Barrel Stand

Bond, an ingredient for manufacturing water based putty is stored in two barrels each about 250kg in weight. To extract bond from the barrel which is placed vertically, it has to be tilted horizontally. Since the barrel is heavy it is required of the worker to use the manual forklift. This operation is broken into the following elements:

1) Bring the manual forklift near the barrel.
2) Walk from manual forklift to bucket.
3) Bring the bucket near the manual forklift.
4) Place the barrel on the manual forklift.
5) Adjust the barrel and manual forklift height in accordance to bucket.
6) Loosen the lid of the barrel by tool.
7) Now open the lid by hand.
8) Pour bond from barrel into the bucket.
9) Close the lid by hand.
10) Close the lid by tool.
11) Walk behind manual forklift.
12) Pull manual forklift back.
13) Drop the manual forklift.
14) Place barrel on its original place.

The movement of barrel (Refer to Fig.7) demands a lot of worker's fatigue so the researcher came up with solution of eliminating the movements involved with barrel by introducing a barrel stand (Refer to Fig.8).

Fig.7- Present Arrangement

Fig.8- Proposed Arrangement

With the introduction of barrel stand the position of the barrel now became horizontal due to which the original operation got reduced from 16 elements to 7 elements:

1) Walk to the bucket.
2) Bring the bucket near the barrel stand containing the barrel.
3) Loosen the lid of the barrel by tool.
4) Now open the lid by hand.
5) Pour bond from barrel into the bucket.
6) Close the lid by hand.
7) Close the lid by tool.

Benefits gained by the barrel stand are as follows

- Elimination of efforts in handling big bond barrel hence improvement in ergonomics.
- Elimination of the unnecessary movement of manual forklift (Refer to the shaded region in Fig.12 & 13)
- Elimination of efforts in moving the manual forklift.
- Reduction in time for extraction of bond from the barrel.

III. Rollers

Packaging of putty is done in a plastic bag which is then placed either inside a bucket or in a heavy duty plastic bag. After batching of the product is over it is extracted from a tapping spout which is positioned underneath the machine exactly in the center of it. The worker temporarily places the plastic bag in a bucket (for easy handling) beneath the tapping spout. After it is filled the worker pulls the bag outside, weighs it and then forwards it further to the other worker for sealing it.

When the bag is full, it weighs around 20 kg and to pull it outside it requires considerable time and effort. To make it easier the researcher proposed a roller conveyor (Refer to Fig.9) to be installed beneath the tapping spout for easier handling and hence improving ergonomics.

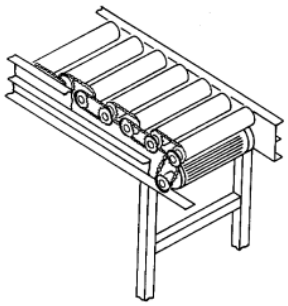

Fig.9- Roller

IV. Zip ties

After pulling the plastic bag out from beneath the machine it is weighed and then sealed with the help of a jute rope (Refer to Fig.10). The researcher found this as a conventional way of sealing and hence proposed another type of fastener which is a zip tie (Refer to Fig.11).

This resulted in elimination of unnecessary elements and hence faster packaging of each bag. It also enhanced the aesthetic appearance of the bag.

Fig.10- Present Jute Rope

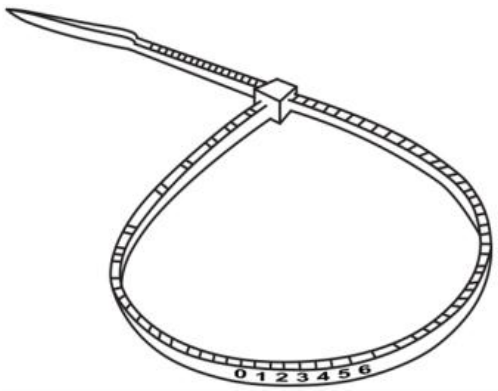

Fig.11- Proposed Zip Tie

V. Stools for the workers and support for stitching

There is no stool for the worker to sit during the packaging operation. Hence with respect to ergonomics the researcher proposed the idea of providing proper stool for the worker including a proper heighted support for resting the stitching machine.

This will help improve the durability of the stitching machine as previously the operator was dropping the stitching machine on the floor from a particular height which lead to frequent breakdowns. Also the introduction of the stool will reduce the probability of back problems for the worker.

The developed methods enabled the researcher to finish with the Flow Process Chart and String Diagram (Refer to Fig.12 & 13) arraying the current and proposed sequence of procedure by recording all the events under review using appropriate chart symbols. As can be seen in the figures the shaded regions depict the area utilized by the manual forklift according to the present and proposed methods respectively. From the proposed string diagram we can conclude how confining the process only to a required area thereby reducing the walking distance of the operator would inturn reduce the fatigue hence would reduce the stress of the operator.

Table 1

S.N	Manufacturing with:	Batching time	Mixing Time	Packaging time	Total Time (hours)	Total time (minutes)	Time Saved
1	Present Method	25.05 min	30 min	56.21 min	1 hr 51.26 min	111.26	17.65 min
2	Proposed Method	22.11 min	30 min	41.50 min	1 hr 33.61 min	93.61	

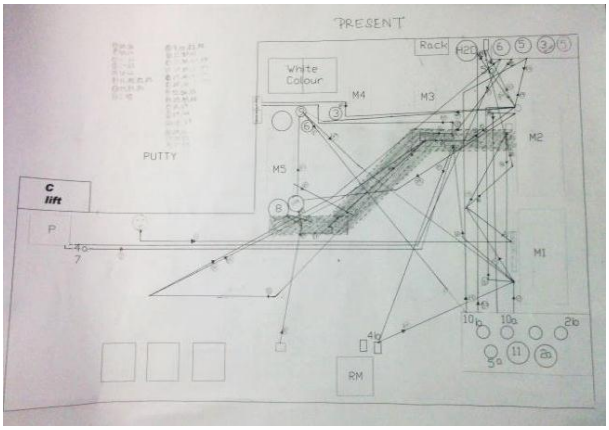

Fig.12- String Diagram of Original Layout

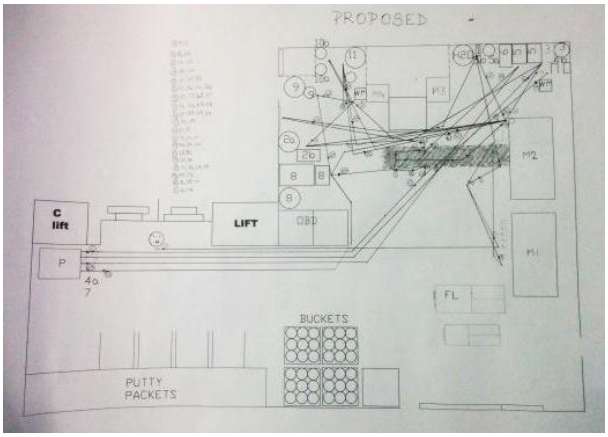

Fig.13- String Diagram of Proposed Layout

2.5. Evaluation of developed methods

a) Time saved after improvement in layout = 1.84 min.
b) Time saved after improvement in material handling= 1.1 min.
c) Time saved after improvement in packaging = 14.71 min.

Therefore, total time saved in 1 batch= 17.65 min.

- Shift Timings 9:30am to 5:30am including lunch break of 30 minutes.
- Total Available time = 450 minutes
- Number of paint bags produced and packed per batch= 52
- Number of working days in a month= 25

With Present Method

- Number of batches that can be performed is

$$\frac{450}{111.26} = 4.04\ batches$$

- Number of paint bags that can be produced and packed in 4.04 batches is

$$4.04 * 52 = 210.08\ paint\ bags$$

- Number of paint bags that can be produced per month is

$$210.28 * 25 = 5{,}252\ paint\ bags$$

With Proposed Method

- Number of batches that can be performed

$$\frac{450}{93.61} = 4.8\ batches$$

- Number of paint bags that can be produced and packed in 4.8 batches

$$4.8 * 52 = 249.6\ paint\ bags$$

- Number of paint bags that can be produced per month= 249.6 x 25= 6,240 paint bags

$$249.6 * 25 = 6{,}240\ paint\ bags$$

- Increment in production of paint bags is

$$6240 - 5252 = 988\ paint\ bags$$

- Therefore, increment in productivity is

$$\frac{988}{5252} * 100 = \mathbf{18.81}\%$$

3. Discussions and Conclusions

This study analyzed the existing state of manufacturing and proposed improved methods, the implementation of which resulted in increased production capacity, improved productivity and reduced human efforts. With the implementation of work study principles, the results of the study were a success. Production operators were instrumental to the success of each improved methods. By applying their knowledge to the processes allowed the researcher to provide the best solutions to the issues within the process. With the increase in productivity by approximately 19% shows

the correct application of industrial engineering techniques can have a positive impact within any company.

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