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Productivity Improvement by Lean Techniques in a Small Scale Industry

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Abstract— In our project, "Productivity Improvement by Lean Techniques," undertaken in Unirols Airtex (P) Ltd, Coimbatore, the core objective is to improve the production capacity of the industry. In order to meet the demand one of the lean manufacturing tools 5S (Sort, Set in order, Shine, Standardize and Sustain) has been implemented successfully to ensure that the workspace is tidy, ergonomically efficient and capable of repeatable, quality output to achieve better efficiency. In addition to this technique, we also analyzed and optimized the layout of the industry using the software VIP-PLANOPT 2006 resulting in the improvement of overall productivity which helps the industry in meeting the demand.

Index Terms—Lean tools, 5S, layout optimization, productivity.

I. INTRODUCTION

Lean is basically "doing more with less" .The Japanese have been pioneers in this field and dominated the field of production with their concept of offering great quality at a cheaper cost. This was possible only through their successful implementation of lean. Toyota is known to have introduced this as a work culture itself. For example, it is the duty of the operator to ensure that the area around his machine is clean. If not, he should but clean it himself instead of expecting the sweeper to do it. The concept of lean was born after the second world war when the Toyota family wanted to convert their loom manufacturing business into an automobile business. Facing stiff competition from Ford in the foreign market and battling constraints like low capital investment, they had to come up with a new production system called Just in Time system. They brought the concept of 'pull' rather than 'push'. Thus, Toyota was successfully able to capture the international market and have now emerged as one of the leading giants in the field of automobiles.

II. IMPORTANCE OF LEAN TOOLS IN PRODUCTIVITY IMPROVEMENT

Japan had learned management and improvement techniques/methods such as industrial engineering (IE) and quality control (QC) from Europe and America. Those methods were further developed in Japan resulting in the emergence of a technique globally known as Kaizen or "continuous improvement". During this movement, Toyota developed their own unique methods in manufacturing. The concept was completely different from the mass production method. Lean manufacturing has the capacity to produce product using the least amount of non-value-adding activities that add time and subsequently, cost to the manufacturing process. The lean methodologies include certain mathematical formulas that balance work being performed to optimize the manufacturing resources necessary to achieve customer demand while helping to model the ideal physical layout of the manufacturing shop floor. The methodology provides an objective set of tools for designing manufacturing processes with minimum wait, move and queue time normally embedded in launched and routed shop-order-based systems, regardless of products manufactured or the processes used to manufacture them.

Changes in productivity within an industry or at the company level are closely related to success and survival. The profit margins realized by an industry or a specific company are directly related to its ability to make productivity gains to counter competition. Industries where competition helps propel improvement often experience greater growth. Companies that fail to keep pace with competition will fail. In either case, all stakeholders are directly impacted. Lean manufacturing is a technique that aims at significantly eliminating waste in the manufacturing process. Owing to limitations in small scale industries like finance, infrastructure all lean tools cannot be implemented. Submit your manuscript electronically for review.

III. PROBLEM DEFINITION

The efficiency of production depends on how well the various machines, services production facilities and employee's amenities are located in a plant. To increase the productivity i.e. the production efficiency of the industry, a well-defined plant layout is mandatory. This can be achieved by the implementation of 5S in the industry and the facility layout optimization. The following problems were identified in the industry.

- The Actual demand is 111 machines per month.
- The Supply is 104 machines per month.
- Demand vs Supply gap is 7 machines per month.
- Cost of 111 machines = Rs 83,25,000
- Cost of 104 machines = Rs 78,00,000
- Loss due to insufficient supply = Rs 5,25,000

IV. OBJECTIVE

The objective of this project is to bridge the demand vs supply gap, thereby reducing the loss due to insufficient supply. The project aims at

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improving productivity by the implementation of 5S and optimization of facility layout. By implementing 5S, a clean working environment can be ensured. The time taken to search for tools, dies is drastically reduced by optimizing the facility.

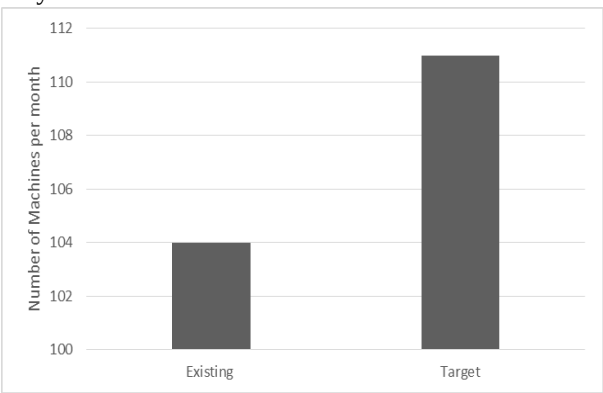

Fig 1 –Bar graph showing the objective of the project.

V. PRODUCTIVITY

A. *Defintion*

Productivity refers to the ratio of Output to Input and the various types of productivity are:

- Total Factor Productivity
- Labour Productivity
- Capital Productivity
- Material Productivity

Some of the ways of improving productivity are by better application of materials, improved processes and machinery, faster production lines and more energy from workers. This study specifically aims at improving the labour productivity which would result in higher through-put, optimal use of human Labour, higher wage for the labourers.

B. *Measurement of Productivity*

$$\text{Productivity} = \frac{\text{Number of machines produced per month}}{\text{Total number of working hours per month}}$$

Number of working hours a day = 8 hours [(8:30 – 1:00) + (1:30 – 5:00)]

Total number of working days in a month = 24 days

Total number of working hours in a month = 192 hours

Total number of machines manufactured in a month = 104

$$\text{Productivity} = \frac{104}{192}$$

Productivity = 0.54 machines/hour

VI. 5S CONCEPT

The five pillars are defined as Sort, Set in order, Shine, Standardize and Sustain. It is one of the working tools of Lean Manufacturing. The program gets its name from five activities beginning with the letter S, which were derived from 5 Japanese words. The words are

1) Seiri.
2) Seiton.
3) Seiso.
4) Seiketsu.
5) Shitsuke.

Thorough implementation of the five pillars of 5S is the starting point in the development of improvement activities to ensure any company's survival which is necessary in order for the company's employees to keep their jobs. Sort and Set in order are the two most important tools for achieving zero defects, cost reductions, zero accidents and safety improvements. The success of improvement activities depends upon them. Sort ensures that only the items that are used stay in the plant. The unused items are scraped. In the set in order phase, the used items are then arranged in a particular order so that location of these items becomes easier and quicker. Shine ensures that the plant floor is clean at all times thus resulting in better safety. Standardization can be implemented through visual controls. Finally, all the concepts are sustained through employee training [9].

A. *Sort*

Sort, the first pillar of the visual workplace, corresponds to the just-in-time (JIT) principle of "only what is needed, only in the amounts needed and only when it is needed." Implementing this pillar creates a work environment in which space, time, money, energy and other resources can be managed and used most effectively. The Red-Tag Strategy is a simple method for identifying potentially unneeded items in the factory, evaluating their usefulness and dealing with them appropriately. Red-Tag literally means putting red tags on items in the factory that need to be evaluated as being necessary or unnecessary[9]. Fig 2 shows the image of a red tag that was used to sort the parts. The red tagged parts were grouped together. The old and unused parts were scraped.

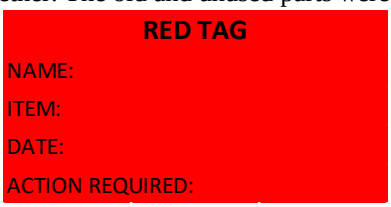

Fig 2 – Red Tag

TABLE I:TABLE DEFINING THE SOLUTION FOR DIFFERENT PROBLEMS

LOCATION	PROBLEM	SOLUTION
Power Press	Too much operator of movement	Need of rack for placement of dies
Behind Manual Rolling machine	Old unused cylinders scattered	Grouping
Mechanical Bending Machine	Idle	Can be scraped
Hydraulic swing beam shearing machine	Sheared components fall on the floor	A tray can be attached for collection
CNC Lathe section	Rejected parts	Can be grouped for scrap or rework
Drilling Section	Scattering of chips	A sheet metal can be placed as a shield
Behind the Drilling section	Unused Aluminium rails	They have to be moved to the inventory section

B. *Set in order*

Set in order means that you arrange needed items so that they are easy to use and label them so that the workers can find them and put them away[9]. This tool is important as it eliminates many kinds of

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waste in production or clerical activities such as searching waste, waste due to difficulty in using items and waste due to difficulty in returning items. Set in order works best when it is implemented together with the first pillar, sort. Fig 3 shows the sheets of different thickness grouped together and placed in a rack.

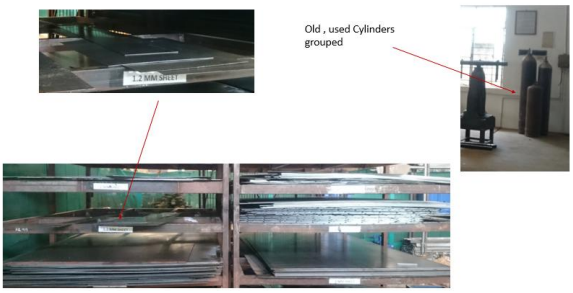

Fig 3 – Set in Order

C. Shine

The third pillar, shine is the component that emphasizes the removal of dirt, grime and dust from the workplace. As such, shine means that everything can be kept clean. Turning the workplace into a clean, bright place where everyone will enjoy working is one of the most obvious purposes of Shine. As a part of shine phase, it was ensured that the chips were collected in a bin so that it is easier to dispose[9].

D. Standardise

Standardization means creating a consistent way that tasks and procedures are executed. There are two types of standardization viz., machinery standardization and operation standardization[9]. Machinery standardization means anyone can operate the machinery. Operation standardization means anyone can perform the operation. The Set in Order pillar is the base for standardization since the workplace must be orderly before any type of standardization can be implemented effectively.

E. Sustain

The fifth pillar is Sustain. In the context of the five pillars, to sustain means to make a habit of properly maintaining correct procedures. The implementation of the Sustain pillar is different from that of the Sort, set in Order, Shine or Standardize pillars in the sense that the results are not visible and cannot be measured. Fig.4 shows the maintenance schedule sheet for the lathe machine.

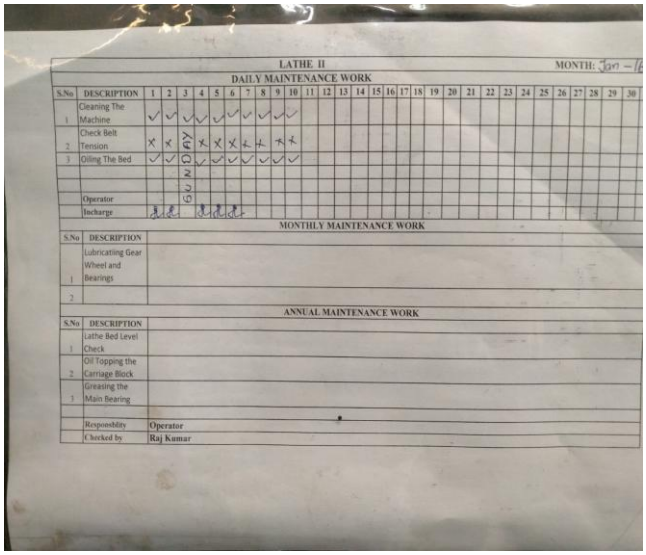

Fig 4 – Maintenance schedule

Fig 5 – Maintenance schedule hung in front of CNC Bending Machine

Fig 6 – Before the implementation of 5S.

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Fig 7 – After the implementation of 5S.

VII. FACILITY LAYOUT OPTIMISATION

Here, VIP-PLANOPT software is used to minimize the material handling cost and also to improve the facilities existing layout by reducing the transportation time in moving the parts from one machine to another.

A. VIP PLAN-OPT Requirements

The following parameters are required for the optimization of layout using the VIP-PLANOPT software [3].

1) Initial layout.
2) Flow rate.
3) Time per unit distance.
4) Total number of departments.
5) Number of fixed departments.
6) Locations of fixed departments.
7) Area of department

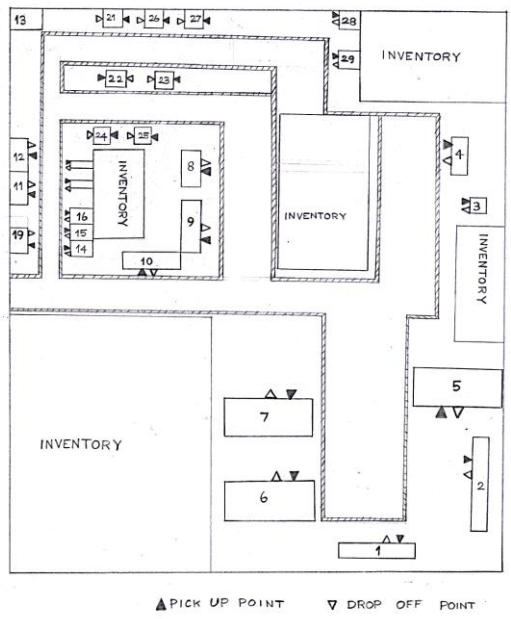

Fig 8 – Old Layout

TABLE II: LIST OF MODULES

Module no.	Module	Dimensions(m)
1	Machine Mechanical Bending Machine	1.48 x 3.1
2	CNC Hydraulic Bending Machine	1.3 x 3.04
3	Power Press	0.86 x 0.86
4	Manual Rolling Machine	0.49x 1.5
5	Lathe	1.09 x 2.1
6	Lathe	1.23 x 2.1
7	CNC Lathe	1.83 x 2.75
8	Shearing Machine	0.98 x 1.45
9	Working table	1.7 x 3.07
10	Electrical Section	1.5 x 2.85
11	Belt Pasting Machine	1.5 x 2.95
12	Balancing machine	1.5 x 3.56
13	Compressor	1.8 x 2
14	Welding Table 1	1.07 x 1.5
15	Welding Table 2	1.07 x 1.5
16	Welding Table 3	1.07 x 1.5
17	Welding Table 4	1.07 x 1.5
18	Welding Table 5	1.07 x 1.5
19	Welding Table 6	1.07 x 1.5
20	Grinding Table 1	1 x 1.7
21	Belt Grinding Machine 1	0.4 x 1
22	Belt Grinding Machine 2	0.4 x 1
23	Cutting Machine 1	0.4 x 1.38
24	Cutting Machine 2	0.4 x 1.38
25	Spot Welding	2.2 x 1.4
26	Drilling Machine 1	0.6 x 1
27	Drilling Machine 2	0.6 x 1
28	Drilling Machine 3	0.6 x 1
29	Drilling Machine 4	0.6 x 1
30	Inventory	9.57 x 8.5

TABLE III: PROCESS FLOW

OVERHEAD TRAVELLING CLEANER - REGULAR BELT DRIVE		
S . No	**Component**	**Process Flow**
1	Bottom box	23--3--2--14
2	Compound Pulley Speed	7--5--1
3	Aluminium fan Dia 350mm	5--12
4	CAP Cross Piece ID 39	5--15--26--27
5	Rail Insert	8--19--26--7--1--16
6	Swivel Rail Clamp	8--2--26--21
7	Swivel Pipe Clamp	8--26--21
8	Filter Box Bottom Sheet	14--1

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9	Filter Box Top Sheet	15--2
10	Holder Plate	16--3
11	Winding Top box	17--3
12	Winding Top box Mouth	18--4
13	Cross Piece 135mm width	14--5
14	Pneumafil TH-Main Sheet	4--16
15	Pneumafil TH-Front Frame	4--17
16	SF FB Back Sheet	1--18
17	SF FB Clamp	1--15
18	SIDE Box Main Sheet for safety door	2--18
19	Ring	2--17
20	Filter Box Leg	2--18
21	Circlip A-15	Outsourcing
22	M6X12 Grub Screw	Outsourcing
23	M6X12 Allen Bolt	Outsourcing
24	M6X16 Allen Bolt	Outsourcing
25	M6X25 Allen Bolt	Outsourcing

This dimensions of each machine were measured using a measuring tape and recorded. The process flow for every component was also recorded. These results along with the cost matrix were fed as input to the VIP PALNOPT software. The optimized layout was obtained and based on further analysis, spaghetti diagram , the new optimized layout was drawn.

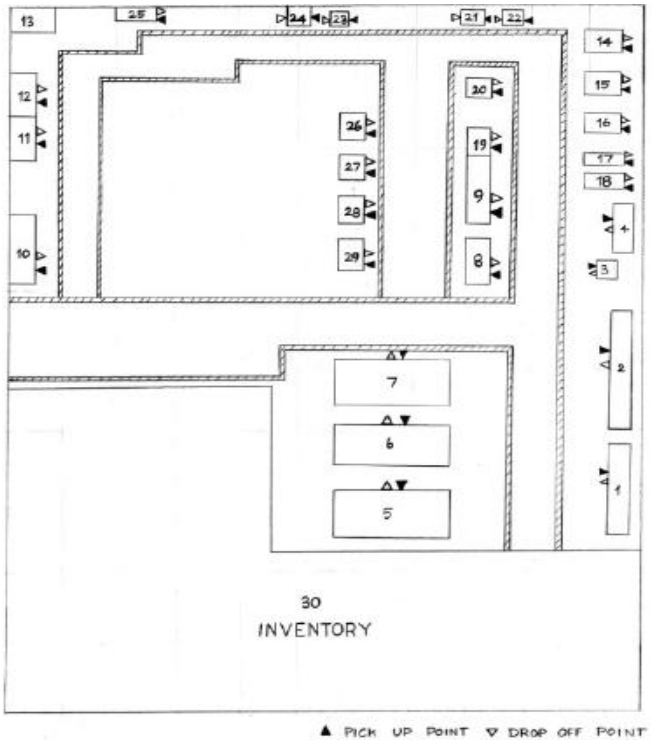

Fig 9 - New Layout.

VIII. TIME STUDY

10 readings were taken using the stop watch for each and every operation,. The transportation time was taken as 0.98 m/s on an average. The results of time of study for Compound Pulley speed, Bottom box, Swivel rail clamp have been tabulated below. Similarly, the time taken to manufacture all the other 17 components was also measured.

TABLE IV: TIME STUDY MADE FOR MANUFACTURING COMPONENTS

TIME STUDY											
COMPONENT	MACHINE	TRIAL 1 (s)	TRIAL 2 (s)	TRIAL 3 (s)	TRIAL 4 (s)	TRIAL 5 (s)	TRAIL 6 (s)	TRIAL 7 (s)	TRIAL 8 (s)	TRIAL 9 (s)	TRIAL 10 (s)
COMPOUND PULLEY SPEED	CNC LATHE	1440	1443	1438	1439	1442	1440	1437	1441	1442	1436
	MANUAL LATHE	623	625	623	622	624	622	623	622	621	625
	MECHANICAL BENDING	386	382	385	384	383	384	385	387	382	385
BOTTOM BOX	CUTTING	5	7	6	4	5	6	8	5	7	5
	PRESS	20	19	20	18	21	21	20	21	19	20
	CNC BENDING	600	597	598	598	603	601	597	602	599	600
	WELDING	1497	1502	1503	1498	1499	1503	1501	1500	1495	1498
SWIVEL RAIL CLAMP	SHEARING	98	99	101	102	101	97	103	96	103	102
	CNC BENDING	895	901	898	896	899	897	902	897	903	898
	DRILLING	238	241	243	237	241	239	241	243	238	240
	BELT GRINDING	603	601	595	608	594	597	602	596	601	605

Manufacturing of bottom box takes more time than all the other components. The Pareto Principle (also known as the 80/20 rule) has been employed which means that by removing 20% of the defects, one can solve 80% of the problem. In this study, the time taken to manufacture the components has been reduced by optimizing the machine placement to reduce the transportation time. Reducing the manufacturing time for bottom box, Compound Pulley speed, and Swivel rail clamp will increase the productivity as they take the longest time to manufacture.

TABLE Va: OPTIMIZED TRANSPORTATION TIME FOR COMPOUND PULLEY SPEED AND SWIVEL RAIL CLAMP

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		COMPOUND PULLEY SPEED	
S NO.	PROCESS FLOW	TIME TAKEN BEFORE OPTIMISATION (s)	TIME TAKEN AFTER OPTIMISATION (s)
1	Transport	12.36	5.29
2	CNC Lathe	1440	1440
3	Transport	13.74	3.2
4	Lathe	623.53	623.53
5	Transport	8.66	4.38
6	Mechanical Bending	386	386
7	Transport	27.71	12.2
	TOTAL TIME TAKEN	2512	2474.6
		SWIVEL RAIL CLAMP	
S NO.	PROCESS FLOW	TIME TAKEN BEFORE OPTIMISATION (s)	TIME TAKEN AFTER OPTIMISATION (s)
1	Transport	9.11	4.6
2	Shearing machine	100	100
3	Transport	8.43	4.2
4	CNC Bending	900	900
5	Transport	9.53	5.6
6	Drilling machine	240	240
7	Transport	6.42	3.79
8	Belt Grinding	600	600
9	Transport	20.16	8.23
	TOTAL TIME TAKEN	1893.65	1866.42

TABLE Vb: OPTIMIZED TRANSPORTATION TIME FOR BOTTOM BOX

S NO.	PROCESS FLOW	TIME TAKEN BEFORE OPTIMISATION*(s)*	TIME TAKEN AFTER OPTIMISATION (s)
1	Transport	34.37	10.21
2	Cutting	6	6
3	Transport	38.24	11.6
4	Press	20	20
5	Transport	15.19	6.9
6	CNC Bending	600	600
7	Transport	15.93	7.3
8	Welding	1500	1500
9	Transport	20.29	8.54
10	Powder Coating	1980	1980
	TOTAL TIME TAKEN	4230.2	4150.55

Time taken to manufacture one machine on an average before optimisation = 6646.15 s

Time taken to manufacture one machine on an average after optimisation = 6227.03 s

Time saved in manufacturing one machine after optimisation = 419.12 s = 6.9mins

IX. CONCLUSION

Thus 5S having been implemented in the industry resulted in a cleaner and safer working environment. 5S training was also given to the operators and a maintenance schedule has been setup. Loss of time due to transportation is one of the 8 defects in lean. Thus by optimizing the layout, the transportation time has been reduced by 6.9 minutes for manufacturing each machine which helps in enhancing the productivity. Instead of increasing the man and machinery resources to increase the productivity, the powerful lean tools like 5S and facility layout optimization were implemented and hence the productivity has been improved from 0.54 machines/hour to 0.58 machines/hour. In other words the monthly target of 111 machines has been achieved, thereby eradicating the loss due to insufficient supply and poor design of the plant layout. This resulted in a monthly savings of Rs 5,25,000. Thus, eliminating the major 8 defects itself can result in improvement of productivity, saving of precious resources like money and time. Hence, both the management and employees would benefit from the higher profits and better wages respectively.

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