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Lean Operational Principles and Practices Effecting in a Manufacturing Concern

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ABSTRACT: The purpose of this research is to apply the lean tools towards reduction of lead time in a compressor manufacturing industry. The study is done on the 2 Hp air compressors. Value stream mapping (VSM) technique is applied in order to create an overview of the entire production flow in manufacturing process, visualize non value added activities and identify process waste. Then suitable Lean tool is used to eliminate the non value added activities. The standard operating procedure is developed and training is given to operators. Line balancing technique is used to balance the total work content among different work stations. It is concluded that with the implementation of lean tools, lead time is reduced and overall equipment effectiveness is improved.

KEYWORDS: VSM, Kaizen, 5S, Overall equipment effectiveness, Lead time, Line balancing.

I. INTRODUCTION

The main aim of study is to reduce the lead time by lean tools. With the proper implementation of lean tools the problems can be solved effectively and the productivity can be increased. The paper discusses about the analysis and implementation of lean tools for lead time reduction. The focus of study is to improve the overall equipment effectiveness and to meet the customer demand by using standard operating procedure and line balancing techniques. Value stream mapping (VSM) is a technique that was originally developed by Toyota. VSM is used to find waste in the value stream of the product. Once waste is identified, it is easier to make plan to eliminate it. The purpose of VSM is process improvement at the system level. VSM shows in normal flow format. However, in addition to the information flow necessary plan and meet the customer's demand.

Kaizen is a methodology that permits to identify the opportunities for continuous improvement in a short period of time, such as days or hours. It is an action-based strategy to apply Lean, JIT, quick result, and time-to-market. In business, results should transform to increase income. But a well-established company focuses on a strategy with much more financial improvement than projected. KAI means change or the action to correct and ZEN means good. So basically kaizen is small incremental changes made for improving productivity and minimizing waste. 5S is a system which helps to organize a workplace for efficiency and optimizes quality and productivity via monitoring an organized environment. 5S was developed in Japan and was identified as one of the techniques that enabled JIT manufacturing. The term refers to five steps-sorts, set in order, shine, standardize and sustain that are also known as 5 pillars of visual workplace. The 5S system is good tool for all improvement efforts aiming to drive out waste from the manufacturing process and ultimately improve productivity.

II. LITERATURE REVIEW

A value stream includes all activities, i.e. value-added, non value-added and supporting activities that are necessary to create a product (or to render a service) and to make this available to the customer. Value Stream Mapping was

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originally developed as a method within the Toyota's Production System and is an essential element of Lean Management. Value Stream Mapping is a simple, yet very effective, method to gain a holistic overview of the status of the value streams in an organization.

NaikShrikantShrikrishna, K.Natarajan, VinayGouda, (2014), Reduction of idle time and process lead time in the manufacturing of rocker arm lines using lean tools. This paper concentrates on the productivity improvement by reducing idle time and process lead time in the manufacturing of process lead time using lean tools. It can be seen that line efficiency before and after heat treatment is improved by 15 % and 17 % respectively and process lead is reduced by 0.31 days. [3].Fawaz A. Abdulmaleka, Jayant Rajgopalb (2006) analysing the benefits of lean manufacturing and value stream mapping via simulation: A process sector case study. They used Value stream mapping as the main tool to identify the opportunities for various lean techniques. we also describe a simulation model that was developed to contrast the "before" and "after" Rajesh Gautam, Sushil Kumar, Dr. Sultan Singh, (2012). This case study deals with the kaizen implementation in an industry in an assembly line in India that manufactures front and rear axle for heavy and medium vehicles. One more interested thing is observed from the study that not a single operator after Kaizen reach to 90% of the takt time. These will results in minimum cost and increase in productivity. [5].Kaizen is a continuous improvement process. Kaizen can Obtain quick results. It rearranges the process. 5S is a workplace organization and continuous improvement system that lays the foundation for all other lean improvement activities. It has been proven to work in any business, every sector, all industries, in any country and has been instrumental in changing the culture of organizations worldwide [7]

III. PROBLEM DEFINITION

The study and observation showed that while the setup time is more. Further observation revealed that they are not meeting the customer demand, because there is no proper assembly of workstations it will increases the manufacturing lead time. Another observation is the machine downtime is more because of improper maintenance. This will causes the less productivity. In machine shop there is no proper handling of 5S activity, this causes for more tool searching time for operators. It will also increase the non value added activity for operators in machine shop. Machine utilization is poor because of improper operating procedure. It causes less production.

Objectives

- To reduce the total lead time
- To improve the overall equipment effectiveness
- To meet the customer demand on time
- To reduce the downtime by increasing the machine utilization
- To reduce the non value added activities

IV. METHODOLOGY

The project methodology starts with the identification of a problem and the detailed procedure to solve that problem. The problems and various wastes are identified within the process which needs improvement. The project continues with the proper time study and then observations are noted down. All the data regarding the problem is collected. Bottleneck operations are found out by using the VSM. Current State VSM gives the exact idea of this. Then suitable solution is found out with the help of lean tools such as Kaizen, 5S, Process improvement and other suitable lean tools. After applications of these lean tools future state is drawn and results are discussed.

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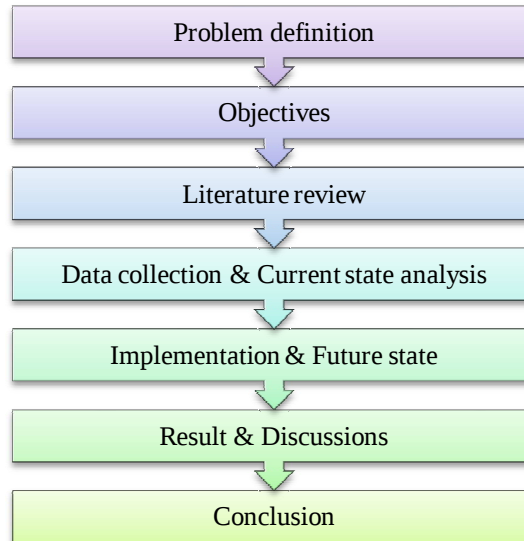


Fig 1: Methodology

V. DATA COLLECTION

Data collection is done for the manufacturing of 2Hp air compressors. First the takt time is calculated for 2 Hp air compressors. Takt time is time required to manufacture the product to meet customer demand. Takt time is available time divided by customer demand.

Table I: Time study

Time per shift	8.5 hrs=510 min
Break and clean up time	60 min
Total available time per shift	450 min
Customer Demand per shift(Average)	8
Takt time=Available time/customer demand	$450/8=56.25$ min

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Table II: Data Collection

Activity	Cycle Time (mins)	Value added time (mins)	Non value added time (mins)
Compressor head machining	09	6.3	2.7
Crankcase machining	57	29.6	27.4
Cylinder machining	33	26	07
Connecting rod machining	7.6	4.6	03
Valve plate grinding	12.2	9.2	03
Shaft coupling machining	05	03	02
Inspection	13	00	13
Assembly	26	20	6
Testing	15	00	15
Painting	11	05	06
Packaging	20.5	16.5	04

After calculation of takt time, VSM is drawn to analyze the time taken by each operation and their setup time. A value stream is a collection of all actions (value added as well as non-value-added) that are required to bring a product (or a group of products that use the same resources) through the main flow, starting with raw material and ending with customer. All the data required for current state mapping were collected. Data collection consists of the process cycle times, changeover times and no of operator required for doing the same operation. Current state value stream mapping is constructed by using I-GRAFX 2013 software. The VSM gives the total lead time required. Current state map is giving the clear picture of the operation and their setup time and processing time. The time study is done for each and every activity. Table II gives the details about the data collection. This data is tabulated based on average values noted. Value Stream Mapping was originally developed as a method within the Toyota's Production System and is an essential element of Lean Management.

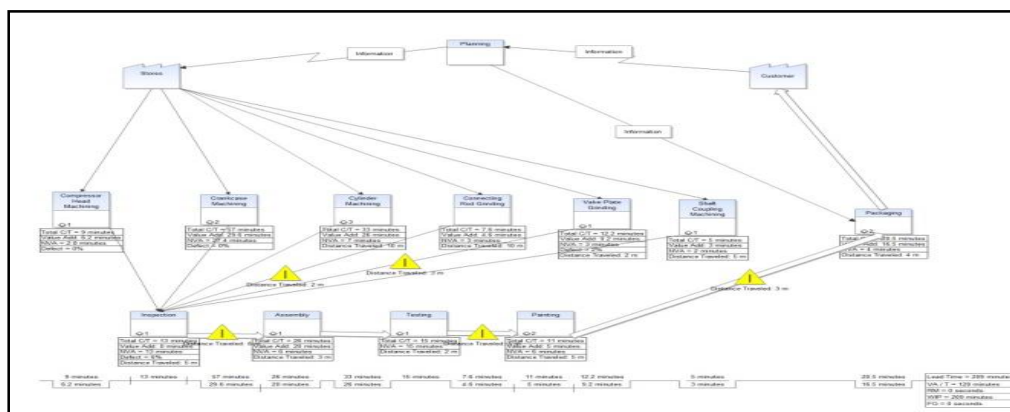


Fig 2: Current state value stream map

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Table III : VSM Results

Description	Time in minutes
Lead time	209
Value added time	120
Non value added time	89

VI. IMPLEMENTATION

Different lean tools are identified to improve the OEE and productivity. After identification of lean tools, each tool is implemented as given below.

A.5S :

5S is a workplace improvement tool. 5S encourages workers to improve their working conditions and helps them to learn to reduce waste. By implementing this tool, time required to search different items is reduced and workplace condition is improved. Fig 3 shows that the tool storage section, here there is no proper arrangement of tools for convenient access to operators. It will increase the tool searching time for the operators.



Fig 3: Before 5S



Fig 4: After 5S

B. Kaizen :

Kaizen is continuous process improvement tool. It is necessary in order to sustain any improvement which is done in the process. Kaizen is a methodology that permits to identify the opportunities for continuous improvement in a short period of time, such as days or hours. It is an action-based strategy to apply Lean, JIT, quick result, and time-to-market. In business, results should transform to increase income. The brainstorming session is conducted and suitable methods are discussed. The best method is selected. The use of proper material handling bins is identified to reduce the non value added activities as well as reduce the labour movements. This bin is designed for storing the raw materials and finished goods. The top portion of the bin is used to hold the tools. This will enable the worker to easily access the materials and tools.

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C. Overall equipment effectiveness:

$$OEE = \text{Equipment availability (\%)} \times \text{Performance Efficiency (\%)} \times \text{Quality Performance (\%)}$$

Table IV: OEE Calculation

OEE factor	Calculated data	OEE %
Availability	301.9/450	0.67=67%
Performance	(35*6.3)/301.9	0.73=73%
Quality	(35-2)/35	0.94=94%
OEE	0.67*0.73*0.94	0.459=45.9%

The implementation of various lean tools and SOP for different machines in the shop floor leads to less downtime of machine, increased output/month, availability, performance efficiency and quality performance which result increase OEE of machine.

D. Line balancing:

The industry manufactures different types of air compressors. The cycle time is very high compared to the takt time. Line efficiency varies from 52 % to 62%. The issues are due to idle time in work stations, improper utilization of labor and bottlenecks. An approach is made using industrial engineering philosophy to solve issues faced in meeting the demand.

$$\text{Takt time} = \frac{\text{Available time}}{\text{Demand}}$$

$$\text{Available time} = \text{Total time} - \text{Scheduled breaks}$$

$$\text{Available time} = 510 - 60$$

$$= 450 \text{ mins}$$

$$\text{Takt time} = 450/8$$

$$= 56.25 \text{ min}$$

$$\text{Theoretical no of workstations (n)} = \frac{\text{Total work content time}}{\text{Takt time}}$$

$$= 193.3/56.25$$

$$= 3.43 = 4 \text{ workstations}$$

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Table V: Activity Details

Operation	Description	Time (min)	Predecessor
A	Compressor head machining	8	-
B	Crankcase machining	45	-
C	Cylinder machining	33	-
D	Connecting rod machining	6.3	-
E	Valve plate grinding	10.5	-
F	Shaft coupling machining	05	-
G	Inspection	13	A,B,C,D,E,F
H	Assembly	26	G
I	Testing	15	H
J	Painting	11	I
K	Packaging	20.5	J

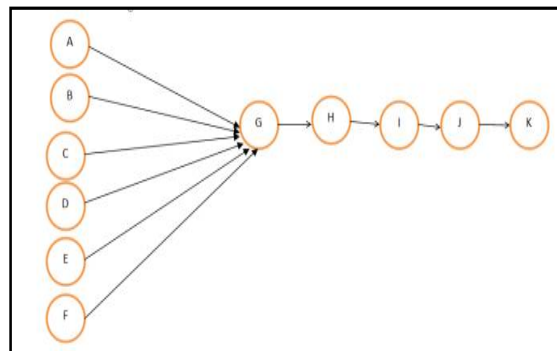


Fig 5. Precedence diagram

Largest candidate rule

Station 1 Station 2 Station 3 Station 4



$$\text{Line efficiency} = \frac{\text{Total work content time}}{\text{No of workstation} * \text{Max station time}} = \frac{193.3}{4 * 55.5} = 87.07 \%$$

Kilbridge westers method

Station 1 Station 2 Station 3 Station 4



$$\text{Line efficiency} = \frac{\text{Total work content time}}{\text{No of workstation} * \text{Max station time}} = \frac{193.3}{4 * 54.8} = 88.1 \%$$

Ranked positional Weightage method

Station 1 Station 2 Station 3 Station 4

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$$\text{Line efficiency} = \frac{\text{Total work content time}}{\text{No of workstation} * \text{Max station time}} = \frac{193.3}{4 * 55.5} = 87.07 \%$$

New heuristic algorithm

Table VI: Activity Details

Successors	Activity	Predecessors	Sum of Successors time (min)
G	A	-	13
G	B	-	13
G	C	-	13
G	D	-	13
G	E	-	13
G	F	-	13
H	G	A to F	26
I	H	G	15
J	I	H	11
K	J	I	22.5
-	K	J	0

Station 1 Station 2 Station 3 Station 4



$$\text{Line efficiency} = \frac{\text{Total work content time}}{\text{No of workstation} * \text{Max station time}} = \frac{193.3}{4 * 50} = 96.6 \%$$

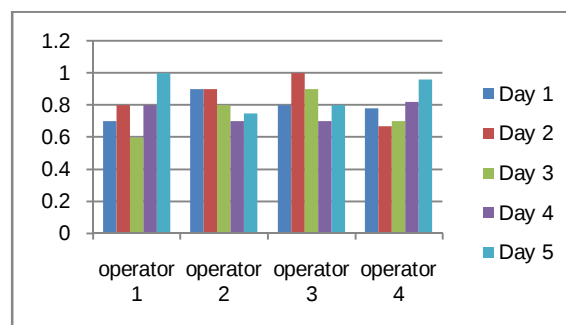


Fig 6.Tool Searching Time

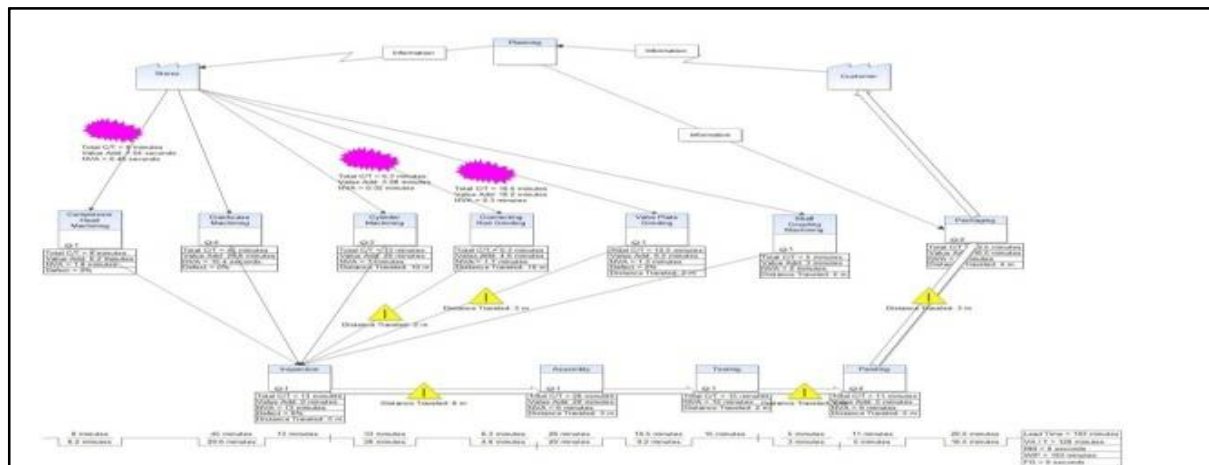
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TABLE VII: OEE Results Comparison

S.no	Description	Before	After
1	Availability	0.67=67%	0.746=74.6%
2	Performance	0.73=73%	0.749=74.9%
3	Quality rate	0.94=94%	1.00=100%
4	OEE %	0.459=45.9%	0.558=55.8%



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VII. RESULTS AND DISCUSSION

After implementing lean tools, tool searching time is reduced as shown in the figure 7 and OEE is improved from 44% to 55% as shown in the figure 8. A future state map is drawn to show the improvements achieved as shown in figure 9 and reduction in lead time of manufacturing of air compressor to 6 minutes as shown in figure 7.

VIII. CONCLUSION

The study suggests the benefits of lean implementation. The results are compared with previous situation that is before implementation of lean tool. By implementing 5S there is significant reduction in non value added time. Kaizen implementation gives the suitable reduction in setup time as well as some small improvements. Process improvements give the reduction in lead time. It is concluded that 5S, Kaizen, Process Improvement, line balancing, overall equipment effectiveness are important lean tools for the lead time reduction and productivity improvement.

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