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APPLICATION OF LEAN PRACTICES FOR IDENTIFICATION OF SOLUTIONS IN REDUCING FURNACE OIL USAGE PER CYLINDER IN KSFPL BY CONSISTENT BATCH PRODUCTION

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Abstract - *Liquid fuels like furnace oil are predominantly used in industrial application. The lack of proper utilization of oil leads to the loss of money in industries. The project is conducting in Kairali Structural Fabrications Private Limited (KSFPL) which is an ISO 9001-2015 Company in Angamaly, Ernakulam. This company manufactures LPG (Liquefied petroleum gas) cylinders for Bharath Petroleum Corporation Limited, Indian Oil Corporation and Hindustan Petroleum. This project mainly aims in reduction of the furnace oil consumption during the stress relieving operation taking place for the cylinder manufacturing. The stress relieving operation is an important operation function for reducing the internal stresses caused by secondary processes such as welding, machining, or cold forming. For the operation of the furnace there is preheating of the entire furnace in which it takes hours to heat the entire furnace before starting the operation which consumes a large amount of fuel. For obtaining maximum efficiency or lesser fuel consumption the entire furnace operations should take place continuously with larger number of works without any delay in the processing. If furnace is operated more than one time in a day the fuel consumed for heating will be very large as the initial heating of furnace is needed in both cases. In this project continues operation of the furnace without delay is taken as the objective to reduce fuel consumption per cylinder. The different lean tools such as 5 why, cause and effect diagram or Ishikawa diagram and value stream mapping (VSM) are employed to identify the above problem leading to fuel consumption and its root cause which is the delay in the production of cylinder and reduced number of cylinders processed per day in KSFPL less than 1000 cylinders which is a batch to be heat treated in a day. The continues operation of the furnace can be made possible by making a value stream map (VSM) which helps to identify the various operations that are bottleneck for the entire operations and more time consuming operations. Value stream mapping (VSM) is defined as a lean tool that employs a flowchart documenting every step in the process. After identifying the time consuming process the lean tools can be employed to make changes to the entire production operations. After current state VSM it is identified the process taking highest lead time. But this problem can be easily rectified and done the modified state VSM and find out that the production of 1000 cylinders per day is possible. This shows that the problem is associated with man, material and machines which is 3M's causing the delay. A fishbone diagram is made based on the plant and 3M's causing delay. Then the future state VSM is made for eliminating most of the problems identified using lean practices. Then the improvements in the future state map can be suggested to the company which helps in reducing the fuel consumption and thereby reduction of fuel cost.*

***Key Words*: Lean, Value stream mapping (VSM), Current state VSM, Modified state VSM, Future state VSM, Ishikawa diagram**

1. INTRODUCTION

As the industries and different companies around the world is moving towards a competitive environment in which they need to withstand the needs and problems associated with the customers and competitors. The best way to achieve competitive advantage is through reducing the wastages and effective utilization of the resources. This can be achieved through the implementation of lean practices in the manufacturing and service industries in which it helps in maximizing the profits and thereby reducing the wastages within the manufacturing organization. The term "lean" denotes the system which uses small amount of inputs and produces a large amount of output as produced by the traditional manufacturing systems with variety of products to the customers. The main aim of lean is to reduce the 7 major types of wastes in kaizen such as waiting, transportation, overproduction, over processing, inventory wastage, unwanted motion and defects. For achieving leanness there are different lean tools such as Kanban, Kaizen, 5s, fishbone diagram, pareto analysis, 5 why analaysis and VSM etc.,

The main aim of this project is to use these lean tools and practices in the company Kairali structural fabrication private limited (KSFPL) Angamaly and to identify the major problem that is affecting the company. Then use these different tools to find the solutions for the problems. The company manufactures LPG cylinders for Bharath Petroleum, Indian Oil Corporation and Hindustan Petroleum. At first stage the problem identification was done and identified that the increased fuel consumption was the major problem in the company. The reason for the problem was no continues batch production of 1000 cylinders was happening

in the furnace. The initial fuel consumption for preheating of furnace is very high and for reducing the consumption continues operations are required at larger number in a day. The company has to process 1000 cylinders which is a batch in the furnace per day but they are not able to do that so by getting into 1000 cylinders per day mark we can reduce the amount of fuel associated with a cylinder. It is identified that as the number of cylinders processing increases the fuel consumption reduces by plotting graph between fuel consumption and cylinders used per day. The root causes for the problem was identified using the 5why analysis and fishbone diagram. Then for identifying the processes causing the higher lead time and analyzing the manufacturing system a Value steam mapping (VSM) was done in which it is consisted of current state VSM in which it identifies the current status of product flow and information flow and the different time calculations are done and mapped the entire manufacturing system upto furnace operation. Using this the process with highest lead time is identified. Then the modified or ideal state VSM was done by rectifying the problem of highest lead time. Then after this the major problems was identified as it is clear that continues furnace operation of 1000 cylinders was possible. Then the future state value stream map is made with kaizen focus on different areas to be improved and provided solutions for that problems using 5s, kanban, Kaizen etc. Then the solutions that are identified and mapped is suggested to the company.

1.1 OBJECTIVES

• To identify the major problem affecting the company

• To use different lean tools to identify the problems.

• Application of different lean tools to identify the solutions for the problems identified.

• Suggesting the solutions to the company.

2. LITERATURE REVIEW

P.G Saleeshya et.al [1] stated that Lean manufacturing is an emerging concept in the Indian manufacturing scenario. Many small and medium scale enterprises in the country are aiming at becoming lean and thereby improving their productivity. This paper deals with a case study in one such enterprise that deals with the manufacturing and assembly of offset printing machinery in India. Thorough analysis of the various vendors and processes that the product goes through was done and the process flow was mapped using VSM. Lean tools like Pareto analysis, five-why analysis, source inspection, etc., were used to identify and eliminate the various factors that led to delay. Lean is a relatively modern management concept which aims at eliminating wastes and increasing efficiency. The term 'lean' denotes a system that utilises less, in terms of all inputs, to create the same outputs as those created by a traditional mass production system, while contributing increased varieties for the end customer.

S. Vinodh et.al [2] VSM is selected as a technique for solving the problem existing in the case organization. The current state map is made using different observations and calculations. The future state map is then created, along with various improvement proposals. For validating performance improvements, a simulation approach is used. The lean manufacturing system enables the manufacturing system to achieve maximum productivity with minimal capital investment and material rejection. The uniqueness of this project is that, in addition to the use of VSM, the improvement in lean performance measures was calculated. A simulation of the production line was also run before and after the recommended proposals were implemented. The outcome of this study has lead to the implementation of stage inspection (SI), fool proofing of jigs and fixtures, etc. in the case company. One of the important techniques of lean manufacturing is VSM which is focused on the micro-analysis of manufacturing processes. He found out that the practical adoption of VSM for ensuring leanness in manufacturing industrial scenario is found to be feeble.

Dinesh Seth et.al [3] stated that the application of VSM is a proven approach for lean-based improvements. Typically, this becomes challenging, when applied for complex production environments. The purpose of this paper is to demonstrate, how with some approximations and simplifications in VSM application, lean can be successfully achieved in these environments. The research follows case study method and systematically guides about the segregation and treatment of non-value-adding(NVA) and value-adding (VA) activities of heavy-duty industrial power transformer making process. The study establishes that VSM application-based lean messages remain same for both simple and complex environments.

. Nihal A Siddiquia et.al [4] Liquefied Petroleum Gas (LPG) Cylinders are manufactured and tested under stringent norms before they get certified by Bureau of Indian Standards (BIS) for market use. These LPG cylinders are designed and manufactured as per Indian standard. Normally, cylinders are produced in batches from raw material specified in Indian standards and tested before dispatching to market. It gives data on the manufacturing process of the LPG cylinder in India and different tests.

S. Vinodh et.al [5] lean manufacturing is focussed on the reconfiguration and restructuring of business processes based on waste elimination, thereby enabling cost reduction. VSM is one of the most important lean manufacturing techniques which is capable of tracking the wastes existing in the manufacturing processes. It was discovered that the VSM implementation contributed to a significant reduction in lead time, total cycle time, work in progress, and defects, as well as a noticeable improvement in uptime and on-time delivery. He

claims that VSM is an effective lean manufacturing technique that could be used in an industrial setting to improve leanness and help organisations achieve competitiveness.

Antor Habib Chowdhury [6] states that Value Stream Mapping is a lean tool used for reducing lead time, uncovering waste in production and supply process by identifying non-value-adding steps first and then removing them. Future state map gives us the view how a manufacturing plant can operate in improved design comparing to the current situation. Improved stage of information flow, material flow and time flow are displayed in the future state map. This method is not easy to use in the case of complex production processes characterized by multiple flows that merge. Applying lean tools such as Kaizen, Go-see & 5S- turn out to be helpful for better material and information flow throughout the production system which reduce lead time.

Sahoo A.K et.al [7] This paper describes an application of value stream mapping (VSM). Consequently, the present and future states of value stream maps are constructed to improve the production process by identifying waste and its sources. The company produces forgings for railways, oil and gas, and the machine tool sector, and also precision forging components for the automobile sectors. It was observed that a smaller batch size always results in a lower waiting time. The complete success of the application of lean philosophy in the long run in the company depends on close cooperation between the shop floor personnel and the management.

Bhim Singh S.K, et.al [8] This paper discuss the lean implementation process and its quantified benefits for the production industry with the help of value stream mapping (VSM). Both current and future state maps of the organization's shop floor scenarios are discussed using VSM techniques in order to highlight improvement areas and to bridge the gap between the existing state and the proposed state of shop floor of the selected industry. After comparison of the current and future state of shop floor of the selected industry it is found that it has halped in saving time in different areas.

Grewal, C.S. [9] states that Value Stream Mapping (VSM) has emerged as the preferred method for implementing and supporting the lean approach. VSM is a useful tool for identifying waste and areas for improvement. VSM allows a company to see the entire process in both its current and desired future states, and to create a road map that prioritises projects or tasks to bridge the gap between the current and future (lean) states. VSM is a graphical representation of the entire value chain

Abdulmalek, F.A. et.al [10] The "lean" approach has been applied more frequently in discrete manufacturing than in the continuous/process sector, mainly because of several perceived barriers in the latter environment that have caused managers to be reluctant to make the required commitment. This paper describe a case where lean principles were adapted for the process sector for application at a large integrated steel mill.

3. RESEARCH METHODOLOGY

The following steps are followed for the completion of the project.

I. Identification of the company

II. Identification of the problem

III. Literature review

IV. Done cost analysis and made graphs relating fuel consumption and number of cylinders processed in a day.

V. Identifying the root causes through 5why analysis and Ishikawa diagram or cause and effect diagram

VI. Value stream mapping of the current condition

VII. Modified or Ideal state value stream map

VIII. Future state or to be state value stream mapping

IX. Suggesting the changes to the company

4. PROBLEM IDENTIFICATION

4.1 COST ANALYSIS

An analysis based on the cost and fuel consumption of the cylinder per day is done for the months November and December for identifying the relation between the fuel consumption and the number of cylinders processed per day. The following graphs were obtained. The graphs in fig-1 and fig-2 it is evident that as the number of cylinders processed increases the consumption per cylinder also reduces. In KSFPL 1000 numbers of cylinder is a batch to be treated in the furnace in a day. As the data shows they are not able to do so. This increases the fuel used per cylinder in a day. So the number of cylinders to be treated is to be kept 1000 for fuel savings.

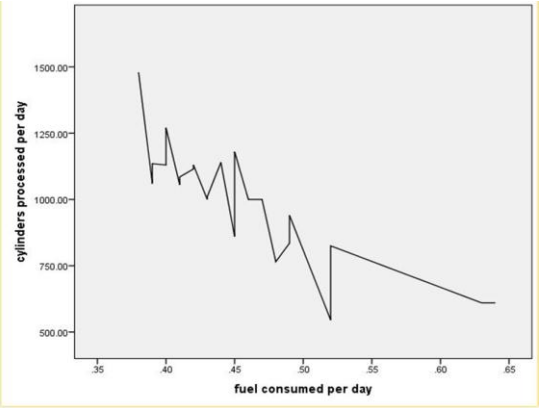

Fig -1: Graph for number of cylinders produced and consumption per cylinder per day of November

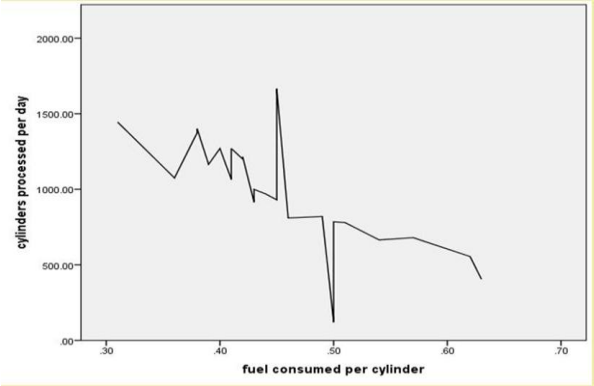

Fig -2: Graph for number of cylinders produced and consumption per cylinder per day of December

4.2 5 WHY ANALAYSIS

5 why analysis is done to identify the root cause of the problem and the analysis questions are as follows,

•Why the cost of oil has increased?

o The increase is because of the increase in consumption.

• Why the consumption has increased?

o It has increased as the continues furnace operation is not taking place.

• Why the continues furnace operations are not happening?

o Because there was delays in the furnace operations due lack of cylinders for processing and also power cut off is also a problem.

• Why the lack of cylinders take place?

o Because it is due to the increased time consumption for the preprocesses before the furnace operations.

• Why the time is high for the above processes?

o Lack of proper arrangement, rework, machine breakdown.

From the 5 why analysis it is identified that the lack of proper arrangement, rework and machine break down are some of the root causes.

4.3 ISHIKAWA DIAGRAM OR ROOT CAUSE ANALYSIS

The cause and effect diagram or Ishikawa diagram is also used to identify root causes for the lack of continues operation in furnace leading to increase in fuel consumption. The fig- 3 indicates the Ishikawa diagram for identification of the root causes for the lack of continues furnace operation.

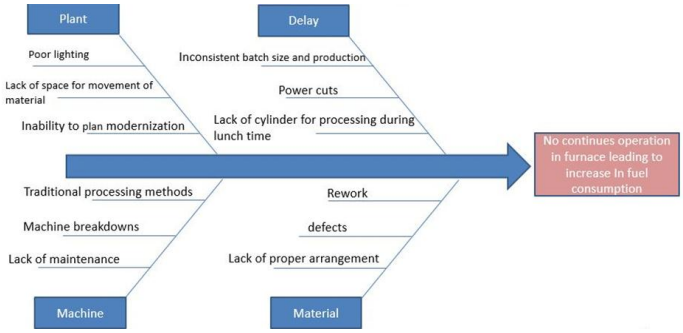

Fig -3 fish bone diagram for root causes

5. VSM DATA COLLECTION AND ANALYSIS

5.1 CURRENT OR AS IS STATE VALUE STREAM MAP

Current state value stream map maps the entire process flow and product flow across the manufacturing organisation from supplier to the customer. In our current state value stream map as shown in fig-4 the mapping is done from supplier to the furnace operation according to the requirement of the project.

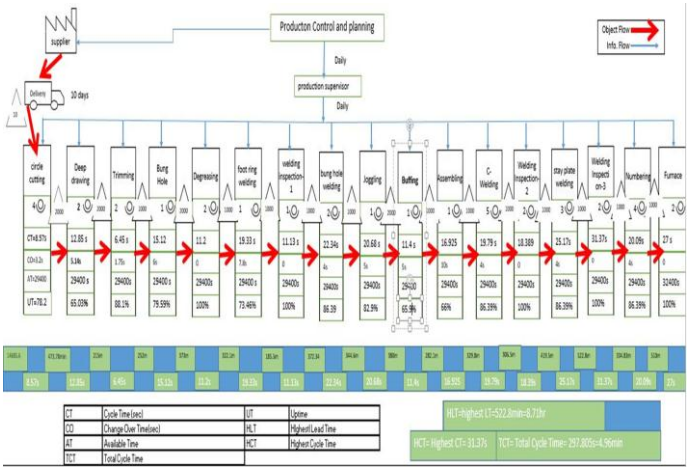

Fig-4: current or as is state VSM

Higher lead time identification and sample calculation is given below,

For welding inspection 3 ,

Working hours= 9.00 Am to 6.00 Pm= 9 hours

Cycle time= 31.37sec

Change over time=0sec

Employees= 2

Lead time = number of inventory× cycle time

= 1000×31.37=31370sec=522.8min=8.71hr

Here this inspection has the highest lead time and this is slowing the entire production time =8.71hr for 1000 cylinders

Also highest cycle time=31.37sec

Major focus is to be given in this area for getting the 1000 batch production

Available production time per day= total available time- break

= 9× 60 - .83(50min) ×60

=490min= 29400sec=8.16hr

Uptime= (available production time- change over time)÷available production time

= (29400-0) ÷29400

=100%

From the available time and highest lead time the time needed extra for 1000 cylinder is

= Highest lead time –available production time

= 8.71-8.16 = .55hr= 33min

33min is required extra for inspecting 63 cylinders.

This problem can be resolved by making some changes and is shown in the modified value stream map

5.2 MODIFIED OR IDEAL STATE VALUE STREAM MAP

The modified or ideal state map is the modified version of the current state map under ideal conditions and it is shown in the below figure fig-5.

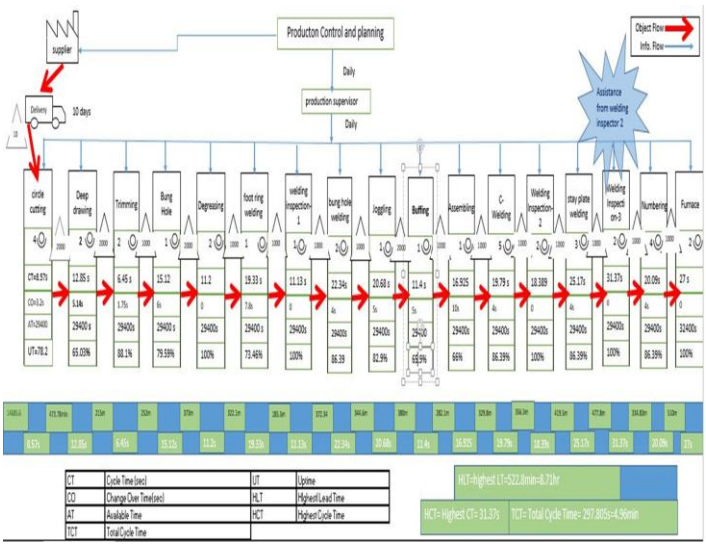

Fig-5: modified or ideal state VSM

After analyzing the current state map the process with highest lead time is find out and the remedy for this problem is found out depicted in the modified state value stream map as shown in the above fig-5. The solution was identified as follows,

- The highest lead time was founded for the welding inspection 3 which is= 522.8min= 8.71 hr.
- It is 33min more than the available time of 8.16 hr (490min).
- This 33min is needed more for inspecting 63 cylinders to complete 1000 cylinders.
- Also the lead time for welding inspection 2 is founded out as 306.5min= 5.10hr which is 3.06 hour less than the available time.
- So in modified value stream map an extra 50 min is given from the inspector 2 for assisting the inspector 3 for achieving the 1000 cylinder batch per day.
- This can be achieved easily as the distance between two is only 10.4meter.
- Then the lead time for welding inspection 2 is increased to 356.5min and for welding inspection 3 it is reduced to 477.8hr (45min reduced) with 5min delay for movement.
- This kaizen focus reduced the lead time for welding inspection 3.

Analysis after modified value stream map,

- From the modified value stream map it is evident that the production of a batch of 1000 cylinders is possible with small changes.
- But here we can see that they are not able to furnace 1000 cylinders per day this pinpoint that there are other major problems within the production.
- This pinpoint to different problems which are identified earlier using 5 why analysis and Ishikava diagram and these can be classified based on the 3M's which are man, machine and material and the plant.
- These can be shown in detail using a new Ishikawa diagram as shown in fig-6.

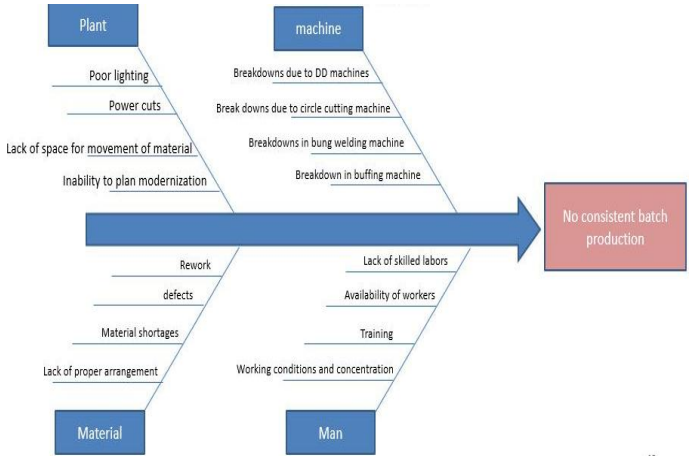

Fig-6: Ishikawa diagram or cause and effect diagram

Table -1: Machines and associated problems

MACHINES	PROBLEMS	OCCURANCE
Deep Drawing machine	• Oil leaks in hydraulic pipe lines. • Pressure variations in pressing. • Slowing down of DD and no drawing.	4 to 5 times in a month
Circle cutting machine	• Gear box break down • Motor complaints with straightener	3 to 4 times a month
Bung welding machine	• Porosity • Positioning of gas torch	2 times or more in a month
Buffing Machine	• Broken belt, shaft wear etc.	less occurrence
Trimming machine	• Limit switch Brocken	Less occurrence
Joggling Machine	• Improper up and down movement • Incomplete joggling process and half falling.	Less occurrence
Bung hole machine	• Hydraulic problems	approximately 2 times in a month
Apart from the above problems there are different electrical problems led to the breakdown of different machines and also during the welding processes there are problems arising due to sticking of weld coil, slow movement of coil, overlapping of weld etc.		

The table-1 denotes the major machines and the problems caused by it and its occurrence.

The future state value stream map is plotted with solutions for most of the problems identified and discussed in the results and discussions.

6. RESULTS AND DISCUSSIONS

• Using the cost analysis and the graphs I have identified the major problem of fuel consumption in which as the number of cylinders processing decreases the fuel consumption per cylinder increases.

• Through direct observations, Group discussions, Making questioners and interviews with employees I have done the root cause analysis using the Ishikawa diagram and 5 why analysis and identified the major causes.

• Then VSM mapping was used to identify the processes with higher lead times causing the delay.

• In current state VSM it is identified that the welding inspection 3 is having higher lead time to inspect 1000 cylinders which is hindering the batch production.

• As shown in the modified state VSM by using a small change it is identified that the batch production was possible within the available time.

• This leads to the identification of the major causes of the inconsistent batch production which are the 3M's Man, Materials and Machines.

• The main causes which are man, material, machine and plant are finded out using the Ishikawa diagram which causes inconsistent batch production.

• As a result the future state value stream map is made as shown in the below figure fig-7 with kaizen focus on different areas to be improved by using different lean tools such as kaizen, 5s, and kanban.

6.1 FUTURE OR TO BE STATE VALUE STREAM MAP

The future state value stream map after incorporating the different solution for the different problems discussed before is shown in the fig-7.

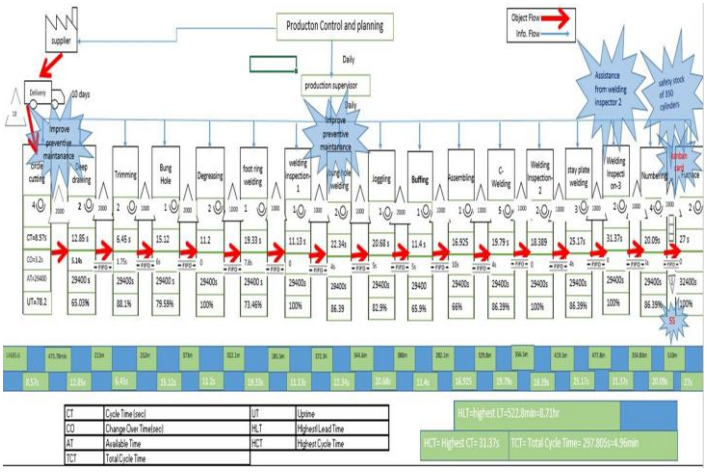

Fig-7: Future or to be state value stream map

➢ As the problems with the machines are a major cause for the delays and the inconsistent batch production the maintenance of the machine is to be considered for the first kaizen focus and also shown in the fig 7.

• It is found out from the maintenance team and VSM that they are mainly focusing on the breakdown maintenance in which maintenance is done only after the machine breakdown.

• It is also identified that the operators who are operating the machines are not well aware of early identification of the problems.

• Also there was cases in which the required parts are not available when a machine break down occurred.

• As a result the future state VSM first kaizen focus is given to improving the preventive maintenance.

• The preventive maintenance can be done by proper checking and analysis of different machines and finding out those parts or things should cause a breakdown and rectifying it earlier.

• Major focus is to be given to machines like Deep Drawing machine, circle cutting machine and bung welding machine.

• For improved preventive maintenance the operators of these machines should be trained and teach to identify the cause of different problems within a machine.

• Before starting the machines at least 15 minutes is to be allotted for checking the machines and also there should be conversations between maintenance team and the operators about the machines.

• It will increase the expertise and knowledge of the operator.

• Proper lubrications and maintenance should be done in proper intervals in daily, weekly and monthly basis.

• Also if a breakdown occurs there should be stock of required parts and materials for the faster recovery.

➢ The second kaizen focus is on furnace which is consisted of allocation of the safety stock, 5s and kanban card.

• A 350 cylinders is to be set as a safety stock for furnace operation to compensate for any delays or breakdown of the machines.

• The 350 cylinder safety stock is taken because 50% of the total lead time can be taken as safety stock in which it is 500 cylinders.

•But here as there will be 60 minutes delay for starting the furnace approximately 100 or more cylinders will came to the furnace so 350 cylinders is taken as safety stock.

• This 350 cylinders can be operated for 2hr and 37mins if there is a delay occurred.

• This time can be utilized to recover the production process by rectifying the problems or repairs and this safety stock is to be filled for next operations if utilized.

• The cylinders will be placed in order in which they will be processed in "first in first out method".

• The cylinders will be stacked in pair of 2 in which they will be placed from one end of the furnace in order to the other end and should be processed from the first end.

• This way safety stock cylinders will be replaced with new cylinders every day.

❖ Area calculation for safety stock,

Outer diameter of a cylinder=319mm= 31.9cm= .319m

Circular area for a cylinder= $\pi r^2 = \pi \times .1595^2 = 0.079m^2$

Therefore for 175(350 Nos) cylinders the area required

$= 175 \times 0.079 = 13.82m^2$

$13.82m^2$ area is required for safety stock of 350 cylinders

Total available area= (main area- unusable area)

$= ((5.5 \times 4.4)-(1.7 \times 1.4))$

$=21.82m^2$

Total number of cylinders that can be stacked

$= 21.82 \div 0.079$

$= 276.2 = 552$ cylinders

So safety stock can be easily placed in this area

- Here a Kanban card which is another kaizen focus utilized to identify the number of cylinders remaining per day for safety stock.
- Here the 350 cylinders are made into 7 sets and the kanban card is used to analyze whether the required safety stock is present.
- For the 350 cylinders of 7 sets the space in which the cylinders are placed is partitioned into different plots and each cylinders will be allocated in required areas in FIFO(first in first out) order through 5s(sort, set in order, standardize, shine, sustain).
- This helps in the orderly management of cylinders to the furnace.
- The kanban card for the safety stock allocation is shown in the fig- 8 for 7 sets of 50 cylinders combining the 350 cylinders safety stock.

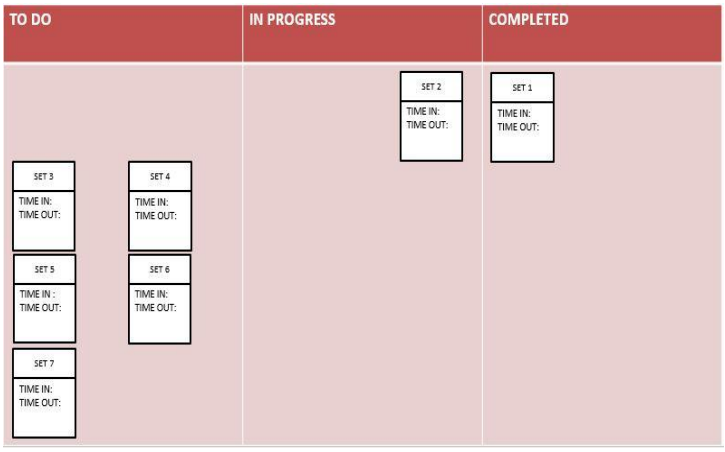

Fig-8: Kanban card for safety stock

- The third kaizen focus on consideration is 5s on the number punching area in which the workers are using 10 dies for number punching in the foot ring and the stay plate.
  - Here the dies are placed in normal boards or nearest surfaces in which there is no specific place for these dies.
  - This causes confusion in selecting the dies while working.
  - To avoid this a box is to be introduced to place these dies with numbers printed with respect to each dies.
  - By this the worker can easily identify the die number and access the dies and can place this box and dies safely.
- The other major focus areas are as follows,
  - Application of 5S is to ensure proper cleaning of the entire production area and also to remove unwanted materials lying in the workplace.
  - The lighting in the area should be improved by adding more lights and proper cleaning of the wall for giving workers good atmosphere to work.
  - Another consideration is to add an employee who is skilled for substituting for stay plate body welding.
  - A kaizen (continues improvement) awareness session is to be done by involving all the employees in the company and should made them capable towards the long lasting change.

At last the above mentioned kaizen focus on the future state value stream map and the solutions that have identified are suggested to the company for improvement in different areas in the manufacturing system and to reduce fuel consumption by continues batch production of 1000 cylinders per day.

7. CONCLUSION

From the project it is identified that the lean practices can be easily applied in a manufacturing company to identify the problems and root cause of each problems. As the project focuses on suggesting solutions for reducing the fuel consumption through lean practices by obtaining consistent batch production. The different lean tools such as 5 Whys, fish bone diagram or Ishikawa diagram were effectively utilized to analyze the root causes in different areas. VSM helped to map the material and information flow along different processes and to calculate the lead times to find process with higher lead times. This helped in making the modified value stream map which helped to identify the solution for process having highest lead time and thereby finding out the major causes of the inconsistent batch production. Then the future state value stream map is made applying different lean practices such as 5s, kaizen, kanban etc. for achieving continues batch production of 1000 cylinders which reduces the fuel consumption. This project helped to formulate different suggestions for the company from the future state VSM to achieve continues batch production

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