IMPLEMENTATION OF LEAN MANUFACTURING TOOLS TO IMPROVE PERFORMANCE IN CIRCLIPS INDUSTRY: A CASE STUDY

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Abstract - Lean Manufacturing is a business strategy that was developed in Japan. The main role of lean manufacturing is to determine as well as to eliminate the waste. Companies implement Lean Manufacturing to compete with their competitors by improving the manufacturing system's productivity and quality enhancement of the product. The main aim of lean manufacturing is to eliminate 'Muda'. Muda is a Japanese word, which means waste. Wastes are of seven types, which occur in any of the industry. These wastes are transportation, unnecessary inventory, unnecessary movement, waiting time, over production, over processing and defects. Lean manufacturing is the improvement process by minimizing and eliminating the waste, which occurs in industry. In this study, one of the well-known tools of lean manufacturing approach called Value Stream Mapping is used. Value stream mapping records all the operations to transform the raw materials into the finished goods taking into consideration the non-value added activities. The purpose of the study is to develop a Value Stream Map for a Circlips manufacturing company in Gujarat. In this study, a current state map is developed to make a sketch of production flow line and understand the current cycle times, change over time, communication process and competence of machine equipment. This gives the information needed to produce a future state map although the company will do that. The aim is to find and eliminate waste in order to progress the process flow. Based on the data collected, the company will utilize these results as an idea to draw the future state map and implement lean manufacturing. The necessary recommendations are made for the use of lean tools to improve the performance.

Key words — Lean Manufacturing, Value Stream Mapping, Current State Mapping, Total Production Lead Time, Total Cycle Time and Available Uptime.

I. INTRODUCTION

Efficiency and competitiveness are two important factors in today's global market that have motivated many manufacturing firms to plan suitable manufacturing strategies. The most critical issue faced today is how to deliver the products or materials quickly at low cost, good quality and in time. Several methods and approaches exist among which lean tools are best suited for improving the quality and productivity by determining the best combination of resources in production lines, construction process, energy, services and supply chains. Lean manufacturing is one of the effective management approaches that has taken by many manufacturing firms in different forms and names.

Circlips manufacturing industries are continually striving to increase productivity and output of their operations. Their objective is to provide the customer with the precise product, good quality and quantity in shortest amount of time along with low cost. Tapping (2002) stated that value stream management is a tool for production planning involving lean initiatives through systematic data capture and analysis. One of the most effective technique of Lean is Value stream mapping technique, which is used in this study to eliminate the non-value added activities (wastes). Wastes include all activities that use resources by imposing cost to the product, but do not have a significant value to the customer. These wastes are to be reduced or eliminated to improve the value added times. Various lean manufacturing tools available for this purpose are cellular manufacturing, just in time, Kanban, Production smoothing, total productive maintenance, Kaizen, 5S and Value stream mapping etc. Among this value stream mapping is selected for the research work.

II. VALUE STREAM MAPPING

Value stream mapping is a visual representation tool for all the manufacturing activities, including flow of material and information, which occurs along the selected value stream for a product or family. It helps to develop flow visualization, identify the wastes, integrate lean principles, decide team and relates material and information flows.

The value stream mapping process have the capability to expose the significant amount of non-value added activities, which ultimately plays the role of loss that are present in current system of the company. These activities consume money as well as resources and increase the lead-time without adding value. However, due to inbuilt limitation of the company some of these activities are present in the system therefore, the idea is to minimize their impact.

III. LITERATURE REVIEW

Authors in their paper have discussed with the value stream mapping which has the reputation of uncovering the waste in manufacturing, production & business process by identifying and eliminating or reducing the non-value added steps [1]. In this paper, the prime objective is to evolve and test several strategies to eliminate waste on the shop floor. This paper describes an application of value stream mapping. Consequently, the present and future states of value stream maps are constructed to improve the production process by identifying waste and its sources. A reduction in cycle time and improvement in cycle efficiency is found [2]. In this paper author says that Value Stream Mapping is a Special type of flow chart that uses various symbols known as "the language of Lean" to show and improve the flow of inventory and information. This tool is used to document current lead-time, inventory levels and cycle times to find the ratio of value added activities to total production lead-time of the product line being analyzed [3]. Researcher had done the research finding on value stream mapping. In his research work, the current state map is created to understand the production flow, cycle time's, communications and machine capacity. From

this a future state map can be drawn which is not done in this paper. The main aim is to identify and eliminate the waste, which is any activity that does not add value to the final product [4]. The goal of this paper is to improve the production line activity of a color industry as a case study. To achieve this goal, lean fundamental principles was used to spot and eliminate the wastes. Based on the future state map, results showed that by implementing some lean techniques, production lead-time and value added time decreased from 8.5 days to 6 days and from 68 minutes to 37 minutes [5].

IV. OBJECTIVES OF PRESENT STUDY

- To examine and collect information related to product and process flow from raw material to finished goods exit point for the value stream selected.
- To create the current state map of the activities by mapping the material and information flow.
- To find out the lean metrics from the value stream selected.
- To analyse the current state map for opportunities spot and eliminate wastes and improve the process flow.
- To make necessary recommendations for improvement in value added time.

V. METHODOLOGY

Step 1: Select a specific product or product family as the target for improvement.

Step 2: Gather information related to product and process flow from raw material to finished goods for the value stream selected.

Step 3: To develop a current state map that is mainly a snapshot capturing how processes are currently being done and calculate lean metrics. Following steps are to be followed to draw current state map.

- **Understanding the customer's demand**
  In this the customers demand is splitted into per day and further calculations are done. As customer is the consumer of the product, its demand rate is to be known.
- **Takt time calculation**
  Takt time is calculated by dividing the available production time per day by overall daily amount of part required.
- **Process flow mapping**
  In this step includes various processes in ascending order required to complete the manufacturing of the product. It is also used to record cycle time and changeover time.
- **Material flow mapping**
  Flow of material from supplier to customer is observed. It helps to know the material flow from which the non-value added time of transportation can be tackled.
- **Information flow mapping**
  Information flow is also incorporated to show information of demand, which is essential for determining the process in system.
- **Total Production cycle time**
  The total cycle time is found out by adding upto individual cycle time of all the processes. After both information and material flow mapping is done, a time line is displayed at the bottom showing the processing time and delay time of each process. It is used to identify the value added and non-value added times (wastes or muda).
- **Other Activities**
  Other activities like placing of order, supply of material etc. are shown by transportation, supplier symbols and information flow lines.

Step 4: Finding opportunities for improvement is to analyze the current state map and further recommendation will be made for improvements. For improvements to be done brainstorming activity is carried out which involves senior professionals and grass root workers working on the machine. Various lean methods are used to eliminate wastes.

VI. CASE STUDY

The case study considered in this work is one of the leading Circlips product manufacturer. The identity of the company is protected and however it can be referred as XYZ Limited. It produces several types of products that are used in various industries like automobile, aerospace etc. The focus of this is on one product family (i.e.) E-clips. The whole process involved in manufacturing is reviewed and data's will be collected based on stopwatch method for cycle time, changeover time etc. The materials used for manufacturing of the E-clips are 80C6. For the value stream selected, the sheets are used, which are received from the suppliers in the form of coils. The E-clips manufacturing involves nine process in this industry. It is a time consuming process and hence is selected for the research work.

The process sequence starts with Slitting operation where raw material available in the form of the sheets are slitted into a particular length. This slitting is done in order to accommodate the sheets in the flattening machine for further operations. After this operation, the cut sheets having a particular length, width and thickness are then pressed between the two rotating rollers to maintain the dimension and uniformity as required. Profile cutting is done to give the required dimension and shape to the clips as per the drawing. Profile cutting is done using punch and die combination on a heavy power press. In this process, there are some wrinkles present on the surface flatness of the E-clips. In order to maintain the flatness coining operation is done where clips are pressed between two flat dies and the required dimension is taken care of.

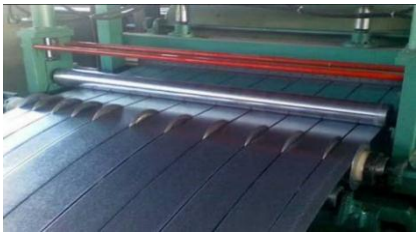

Fig 1. Slitting Operation

Fig 2. Flattening Operation

Fig 3. Profile cutting & Coining Operation

After coining process, the circlips are placed on the constant mesh belt, which passes through the furnace having a total length of 3600mm moving with a speed of 200mm/min. There are three zones maintained at a temperature of 800, 820 and 830 ◌C respectively. After passing through the belt the circlips fall into the salt bath (423 ◌C) where they are soaked for about 12 min. Hardness required for the E-clips is maintained in this process only to avoid the tempering process to be done. This is the Austempering Process.

The burrs, sharp edges, scale formation and degreasing of the clips is done using ceramic stones. A suitable chemical is introduced into the tub along with the ceramic & clips and machine is operated for about 15 ± 5 mins. All the clips are dried after drying operation. This is the process of preparing the clips for phosphating operation or termed as coating operation to prevent from rust. Here the circlips are introduced into the phosphating bath at a temperature of 90 ± 5 ◌C for about 15 ± 5 mins. SS-8400 and user defined standards are used in this process. It is a quick process and depends upon the activity and experience of the worker.

Fig 4. Vibro Process

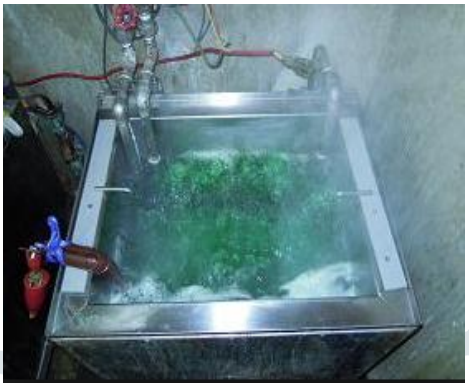

Fig 5. Coating Process

Fig 6. Inspection Area

Oiling is done to prevent rust formation during transportation. The final work to be done is inspection of circlips. Parameters inspected are Inner and Outer diameter, Gap, Thickness, Width and hardness. Visual inspection is done related to coating, burrs, sharp edges and rust. Bend and twist test are performed to check strength. After the final inspection is done and approved by the inspector the product is send for packing and dispatch to the consumer.

VII. METRICS FOR COMPLETE VALUE STREAM SELECTED

For calculating the metrics, the production line data collected are as follows:

- Customer demand for 10 days (excluding holiday) = 60,000 parts
- Customer demand per day = 6000 parts
- Working Shift per day = 2
- Working hours per shift = 8 hrs
- Available time per shift = 480 minutes
- Tea breaks per shift = 2breaks * 15 minutes = 30 minutes
- Lunch break per shift = 30 minutes
- Downtime per shift = 0
- Available production time per shift = (Available time-(breaks+breakdown)) = (480-60) = 420 minutes.
- Available production time per day = 2shifts * 420 minutes = 840 minutes.

Once the information was collected the subsequent metrics for the complete value stream: Available Uptime, Work in process inventory, TCT (Total cycle time) and TLT (total lead-time) and Takt time is found.

- **Uptime % -** Uptime means the actual time for which the machine and resources are utilized to add value to the product. The Average uptime was found to be 97.67%. In similar manner, available uptime is calculated for the entire value stream and is shown in the current state value stream map.
  Uptime % = (Available production time – COT) / Available production time.
  Example for the slitting process:
  Uptime % = (840-15)/840 = 98%.
- **Work in Process Inventory -** The total inventory resolves from by adding up WIP inventory between every method leading to a complete of 60,000 parts in the entire stream.
- **Total Value stream days of WIP & Total Cycle Time -** Total days of WIP inside the value stream resolve by dividing the amount total value stream WIP (60,000) by the daily quantity of components needed by the client (6000 parts) outcome is 10days. The total production cycle time was calculated by adding up the cycle time determined for every of the processes leading to 279 minutes.
- **Lead Time & Takt Time -** Lead-time is that the time from first operation to last operation. It takes 12 days to complete a customer order. The Takt time is resolved by dividing the available production time per day (840 minutes) by the overall daily amount of clips required (6000), resulting in 8.4 seconds. The Takt time gives average time required to manufacture one part at all the workstations.

VIII. CURRENT STATE MAPPING

In order to map the current state, shop floor was travelled to gather information, which began with the receiving space and worked toward the shipping space.

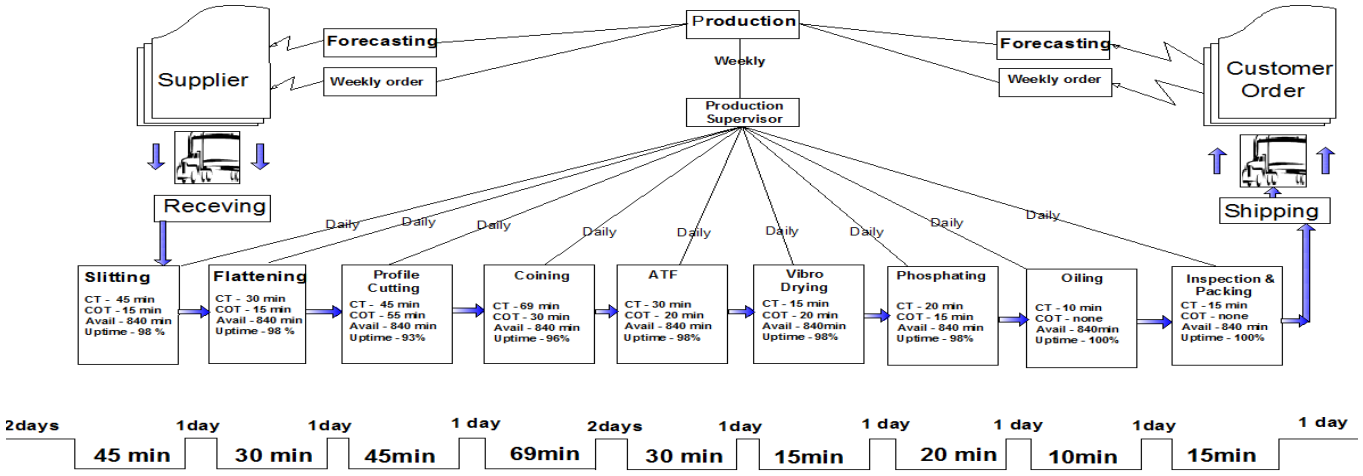

Fig 7. Current State Map

IX. RESULT AND DISCUSSIONS

The purpose of this study was to develop a worth stream map for the E-clips. This explicit tool permits the organization to document current lead-time, available uptime and cycle times. To draw current state map, the researcher observed and collected up information regarding material and information flow paths and process attributes that helped to work out metrics for every method and for the whole value stream. This information helps to develop the value stream map of the method activities and helped to know the movement of materials and information along the selected value stream. This information may be used to spot and eliminate waste within the production method and to supply a future state map by making a vision of a perfect value flow.

It was found that the time it takes to create the full product cycle time for the value stream, 279 minutes. However, the entire lead-time, that is that the time to create a raw material into a finished product was 12 days. The lead-time (12 days) minus the cycle time (279 minutes) is that the non-value-added activities like putting in machines, moving materials, and looking forward to materials. This means that there is a lot of chance for improvement.

Uptime of the Profile cutting and coining operation is affecting the results of the full value stream and will be the cause for delays on delivery of orders. It is observed that every operator runs the work center in numerous ways i.e, the operator's modification of the tools in numerous ways and spending 30 minutes to 1 hour for lining up the work center. The speed of the method depends of the abilities of every operator.

In addition, generally the work centers were not running for the rationale that they had mechanical issues because of poor maintenance. Once the components were created, they spent an excessive amount of waiting time before they were moved to consequent operation. There is poor communication either between the machine operators, production supervisor and forklift operators. Plenty of defective components were found anywhere near the assembly section; there was no specific place for defective materials. In overall, the place perceived to be disorganized.

X. RECOMMENDATIONS

In order to boost the complete production method for the value stream selected, the subsequent recommendations are created. These recommendations are not validated in this case study. It is the responsibility of the company to work over it and ripe the benefits for long time.

It is found that the slitting and flattening operation can be avoided by the use of new technology machine called as Automatic Sheet Flattening machine. This machine is placed just prior to the profile-cutting machine. The coils of sheet are mounted onto the flattening machine and the one end of sheet is fed to the profile-cutting machine. The servomechanism and combination of certain sensors is used due to which there is continuous flow of sheets into the profile-cutting machine and with the help of punch and die combination the profile is generated. This reduces the slitting and flattening time and produces a continuous flow in the production process.

Fig 8. Automatic sheet flattening machine

In order to reduce the changeover time at the Profile cutting and coining section for the E-clips, it is instructed to apply the fast changeover / setup reduction techniques. This setup reduction technique is based on the principles of the single minute exchange of dies system to scale back or eliminate the changeover time. Some examples that can be considered are like setting tools near the work center will reduce the time for the operator spending in searching for the tools.

- Standardization of the setup operations, therefore every operator should perform the setup within the same method and should run

the work centre equally.

- New operators should be trained on the fast change over techniques to avoid delays.

In order to increase the potential capability of the plant while not increasing the capital investments and avoiding unplanned equipment downtime, the implementation of Total Productive Maintenance will be helpful for the lifetime of the equipment concerned. One important part is employee and management involvement, therefore every operator should be looked after for the work center he or she operates, maintain it, and report the injury if it happens and management has to respond appropriately. If shop floor employees are giving any valid suggestions, it should be appreciated and if possible should be rewarded then only the workers will dedicatedly involve in their work.

In order to improve the house keeping activity implementation of 5S techniques for the workplace standardization and organization is suggested. It is one of the best lean tools, provides immediate results, crosses all business boundaries and is applicable to every function within a corporation. This system includes the implementation of 5 steps: take away all unneeded things, produce space for the required things and keep everything clean after utilization, set standards and procedures.

To enhance communications, it is instructed to use visible management systems i.e, techniques that might be applied like decision lights, Andon board lights, digital show panels and a monitor screen. Decision lights and Andon board lights are used to make decision immediately for a supervisor or general staff for various styles of help (e.g. move material, drawback within the line etc.). Digital show panels are another recommendation that might normally be used to point out the range of units that has been created throughout the day. This gives information to everyone at the plant regarding at what rate they have to operating to satisfy clients demand. Due to this visual management system, communication will be generally simplified.

It was found that there was lot of wastages of the E-clips when they were introduced into the soaking tank of the Austempering furnace. Because these E-clips are small in size they are stuck to the conveyors, fall in the cavities in the conveyor and the outcome is reduced. In order to avoid the loss, it is suggested that the company makes use of small packets to fill the clips and then send to the Austempering process. Due to this, all the parts will be available after the process.

To avoid wastages of oil during the oiling operation it is recommended to make use of oil tanks with small pump. When clips are placed in tank with the help of pump the oils will be sprayed onto the clips and the same oil will be reused from the bottom of the tank by connecting it to the inlet of the pump.

In order to reduce the waiting time between every operation, the use of Kanban systems is suggested. It is a tool to attain just in time activity. By use of this tool, the parts are often rushed from one work center to another, improving the product flow and reducing the work-in-process inventory between processes. Cross training of every workers will provide with the facility to accomodate employee absence. This in turn will lead to development of the organization.

XI. CONCLUSION

Value stream mapping tool has proven to be the success way to analyze a firm's current state and find the crises areas. This analysis carries proof of real benefits in applying lean manufacturing techniques in industries. The goal of this study was to collect necessary information and develop a value stream map of the E-clips for the industry. This map served as a basic tool for the researcher to form observations and recommendations to improve the processes in the industry. It was evidenced that value stream mapping is a perfect tool to reveal the waste in value stream and determine improvement areas. This case study exhibits the effectiveness of value stream mapping technique in an exceedingly systematic manner. By combining information and material flow on one map, it depicts how the two relate to the lead-time. It is recommended that the manufacturing industry utilizes the ways developed during this case study work. Eventually it allows the businesses to achieve their final goals resulting in profitability and to withstand in competitive global market.

XII. REFERENCES

[1] Anupam sihag, Vinod Kumar and Umed Khod, "Application of Value Stream Mapping in Small Scale Industries", International Journal of Mechanical Engineering and Robotics Research, ISSN 2278 – 0149, Vol.3, No.3, July 2014. pp 738-746.

[2] D. Rajenthirakumar, P.V. Mohanram and S.G. Harikarthik, "Process Cycle Efficiency Improvement through Lean: A Case Study", International Journal of Lean Thinking. Vol.2, Issue 1, June 2011. Pp 46-58.

[3] Ghanshyam Macchi and Sanjay C Shah, "Review Study on Lead Time Reduction through Value Stream Mapping". JETIR (ISSN: 2349-5162), Vol 1, Issue 7. Dec 2014. Pp 863-866.

[4] Juan C. Tinoco (2004). Implementation of lean manufacturing, Master Diss., University of Wisconsin- Stout, WI. Pp 1-65.

[5] Jafri Mohd Rohani & S M Zahree, "Production Line Analysis via Value Stream Mapping: A Lean Manufacturing of Color Industry", Procedia Manufacturing 2 (2015). Pp 6-10.

[6] K.Venkatramana, Vijaya Ramnath, V.Muthu Kumar, C.Elanchezhiand Procedia Materials Science 6 (2014). Pp 1187 – 1196. 3rd International Conference on Materials Processing and Characterisation (ICMPC2014).

[7] K.T. Sattarova, "Analysis of Organization of Production Process on the basis of Value Stream Mapping", VII International Scientific Practical Conference. IOP Conference series: Materials Science and Engineering 142 (2016). Pp 1-6.

[8] L K Sharma, R M Saxena and Dr. Lokesh Bajpai, "An Explanatory Study of Lean Practices in Job Shop Production/ Special Job Production/ Discrete Production/ Batch Shop Production Industries", International Journal of Engineering Research and Applications, ISSN: 2248 – 9622, Vol.4, Issue 5, May 2014, pp. 94 – 101.

[9] Mehul Mayatra, N.D. Chauhan and Parthiv Trivedi, "A literature review on implementation of Lean Manufacturing Techniques", International Journal of Advance Research, Ideas and Innovations in Technology. Volume 1, Issue 4.

[10] Nirav Patel, Naresh Chauhan and Parthiv Trivedi, "Benefits of Value Stream Mapping as A Lean Tool Implementation Manufacturing Industries: A Review", IJIRST, Volume 1, Issue 8, Jan 2015. ISSN: 2349-6010. Pp 53-57.

[11] Norani Nordin, "A Survey on Lean Manufacturing Implementation in Malaysian Automotive Industry", International Journal of Innovation, Management and Technology, Vol.1, No.4, Oct 2010.ISSN: 2010-0248. Pp 374-380.

[12] R.K. Mehta, D. Mehta & N.K. Mehta, "An Exploratory Study on Implementation of Lean Manufacturing Practices", (With special reference to Automobile Sector Industry). Celal Bayar University IIBF, Manisa. 19/2 (2012). Pp 289-299.

[13] Rahani AR, Muhammad al-Ashraf, "Production Flow Analysis through Value Stream Mapping: A Lean Manufacturing Process Case Study", Procedia Engineering 41 (2012). Pp 1727 – 1734, International Symposium on Robotics and Intelligent Sensors 2012 (IRIS 2012).

[14] Rasli Muslimen, Shari Mohd Yusof and Ana Sakura Zainal Abidin, "Lean Manufacturing Implementation in Malaysian Automotive Components Manufacturer: A Case Study", Proceeding of the World Congress of Engineering 2011, Vol. 1.July 6-8 (2011), London, UK.

[15] R.Sundara, A.N.Balajib and R.M.SatheeshKumar, "A Review on Lean manufacturing Implementation Techniques" Procedia Engineering 97 (2014) pp 1875 – 1885.

[16] Supareuk tarapituxwong and Dr. Chackrit Duangpatra, "Production Process Improvement using Value Stream Mapping: A Case Study of Organic Coffee Firms in Thailand", The Far Eastern University. Pp 128-133.

[17] Santosh B. Dighe and Abhay Kakride, "Lean Manufacturing Implementation Using Value Stream Mapping: A Case Study of Pumps Manufacturing Company", International Journal of Science and Research. ISSN: 2319-7064. (2012).Pp 2492-2498.

[18] S. Nalluswamy and D. Sri Lakshmana Kumar, "Applications of Lean Execution Through Value Stream Mapping in A Water Pump Manufacturing Industry", International Journal of Research in Mechanical, Mechatronics and Automobile Engineering. ISSN: 2454-1443, Vol. 1(4), pp.130-138, 3 Feb 2016.

[19] S.P. Vendan and K. Sakthidhasan, "Reduction of Wastages in Motor Manufacturing Industry", Jordan Journal of Mechanical and Industrial Engineering. Vol.4, Number 5, Nov 2010. ISSN: 1995-6665. Pp 579-590.

[20] Trupti Nandikolmath, Piyush Kumar Pareek and Vasantha Kumara S A, "Implementation of a Lean Model for Carrying out Value Stream Mapping in a Manufacturing Industry", International Journal of Mechanical Engineering and Robotics Research, ISSN 2278 – 0149, Vol.1, No. 2, July 2012.

[21] V.R. Muruganantha, K. Govindaraj and D. sakthimurugan, "Process Planning through Value Stream Mapping in Foundry", International Journal of Innovative Research in Science, Engineering and Technology. ISSN: 2319-8753. Vol. 3, Special Issue 3, March 2014.

[22] Vaibhav S. Kengar, "Manufacturing System Performance Improvement by Value Stream Mapping a Literature Review", International Journal of Innovative Research in Science, Engineering and Technology. Vol. 2, Issue 9, Sep 2013. ISSN: 2319-8753. Pp 12709-12717.

[23] Yu Cheng Wong, Kuan Yew Wong and Anwar Ali, "A Study on lean manufacturing implementation in the Malaysian Electrical and Electronics Industry", European Journal of Scientific Research. ISSN: 1450 – 216, Vol. 38, No. 4 (2009), pp. 521 – 535.