Value Stream Mapping as a Tool for Lean Manufacturing Implementation- A Review

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ABSTRACT: **In today's global competitive world, the era of mass production and pull system is over and companies are experiencing a heavy pressure because of globalization. Main objective of any organisation become satisfying customer requirements. Value is now defined by customer point of view as customer willing to pay and what worthiness that product has for them. They will not pay for any waste and companies have to be focused on this. Thus, companies need to implement Value Stream Mapping (VSM) because it has been established as one of the best and most convenient tools of lean manufacturing implementation and to identify and eliminate all kind of wastes. After creation of current value stream map(CVSM) showing all the processes contributing to product manufacturing, Future value stream map (FVSM) helps to identify and reduce NVAs in a process and make a production flow efficient, effective, economic and flexible. This paper discusses comprehensive literature on implementation of lean manufacturing by using value stream mapping as an effective tool. The methodology to implement value stream mapping and its benefits to various production industries as well as in service sectors has also been discussed. The case studies considered in this paper are from various international researches. The paper concludes with highlighting VSM's contribution to delight customers.**

Keywords: Lean Manufacturing (LM), VSM (Value stream map), CVSM (Current state value stream map), FVSM (Future state value stream map), VA (Value added activity), NVA (Non-value added activity), Kaizen, WIP, Lead Time.

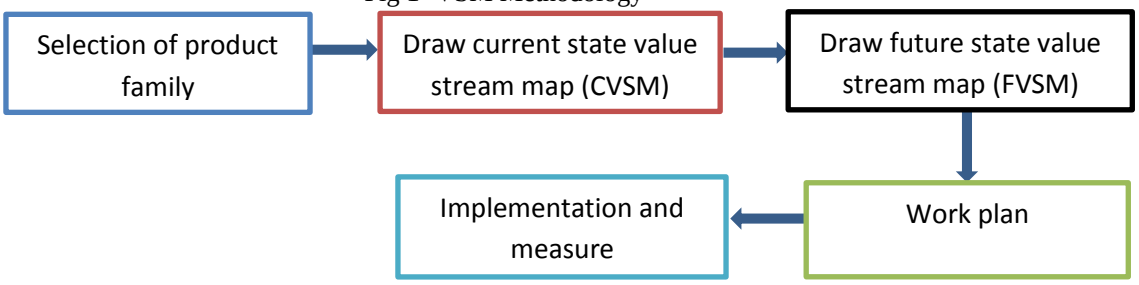
INTRODUCTION

To ensure competitiveness in this high pressured continuous changing and developing market conditions, implementation of lean manufacturing is become necessary for organisations. Lean manufacturing is identified as a comprehensive set of much effective techniques for waste identification and its elimination from processes in order to enhance system flexibility, effectiveness, efficiency and reduce overall production costs. One of the most common and convenient way to implement lean manufacturing is the application of Value Stream Mapping (VSM). Before going to define VSM, we must understand what is value? Value of the product is measured at end users (customers). Value of the product for customer is in terms of money, satisfaction, performance, service or elegance. To serve the best value to the customers company needs a customer requirement data. This data become helpful to make a right product for right customer with right specification at right time with right price. To make this entire system correct VSM is the most common and helpful tool to make entire stream valuable and to eliminate non-value adding activities. Value Stream Mapping (VSM) is a set of methods to visually display the flow of materials and information. Whenever there is a product for a customer, there is a value stream and the change lies in the seeing it. Value Stream map is also known as "Material and information flow mapping" in Toyota. It is developed by a work carried out by Taiichi Ohno at Toyota in the 1960's - 70's. VSM doesn't require a tough and tedious work. It requires just a paper, pencil tool to draw CVSM and FVSM and brainstorming sessions for improvements and comments. In one project there are two value stream maps. A current state map (CVSM) and a future state map (FVSM). A current state value stream map shows what is the actual processing steps are at the beginning of a project. It identifies wastes and NVAs. The future state map shows what the process should look like at the end of the project? And how these processes can be improved? After these improvements as they are suggested changes in current system are made. Now, This FVSM will be the CVSM for next project. And this cycle continuously goes on. We can use VSM as a Lean method to identify the opportunities of improvements for future. VSM method is associated with production as well as with service sectors. It can be used for Reduction in lead and cycle time of various processes, Customer satisfaction and value addition, Managing supply chain activities, Development of efficient production techniques, Improving productivity and profitability, Layout and equipment modification etc.

METHODOLOGY

The methodology for implementation of value stream mapping is essentially having five steps. These all steps are to be performed in a sequential way. The sequence is as follows-

Fig 1- VSM Methodology



1. **Selection of critical product family**-
   The first step is the selection of the product family from the product mix for study. This critical product family should be chosen after studying the product mix thoroughly. This product family will be the ground for further study.
2. **Drawing current state value stream map**-
   Data regarding the customer demand and company production should be collected in this step and data regarding processes and operations should be used to develop a current state map. This map will show the present scenario of the organisation. A wide range of the data related to supply and demand can be analysed by using current state map.
3. **Drawing future state value stream map**-
   After thoroughly analysis of CVSM, future state map will be developed depicting the various modifications and improvements incorporated in current manufacturing processes. FVSM shows ways to improve a process. After analysing the existing processes of an organisation, various proposals and suggestions for waste elimination and process optimization can give a way to the organisation for future improvements.
4. **Work plan**-
   By using various lean tools, an organisation have to develop and select best and optimized implantation plan in order to achieve improvements in best acceptable ways. Some VSM symbols are used in VSM drawing for easy and comprehensive understanding. Some basic symbols are shown in fig 2.
5. **Implementation and comparison**-
   This step shows the implementation of various suggestions made in FVSM. After implementation it becomes necessary to compare the outcomes with existing data. This shows us that how effectively the improvements are made and what the possible benefits could be.

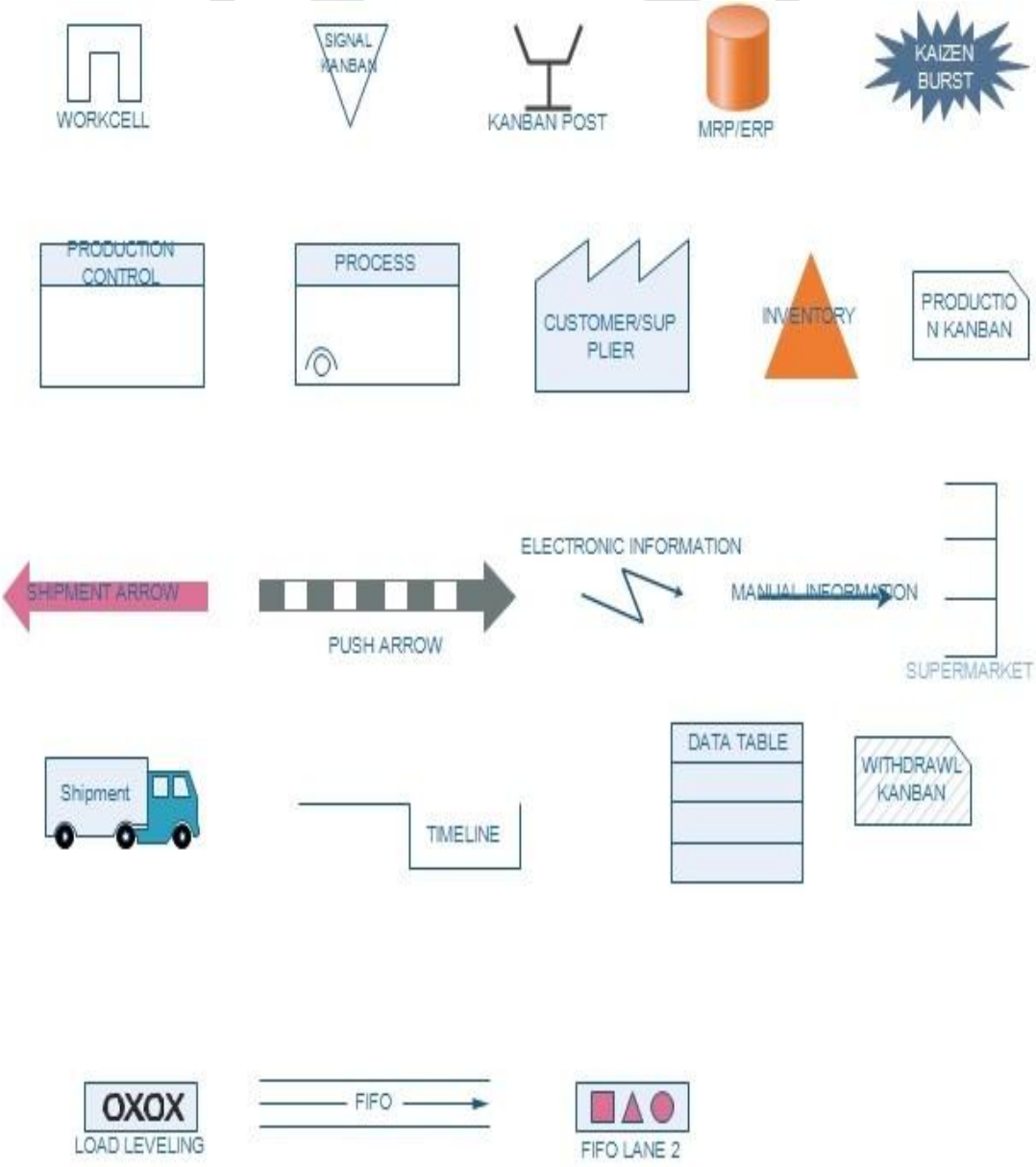


Fig 2- VSM Symbols

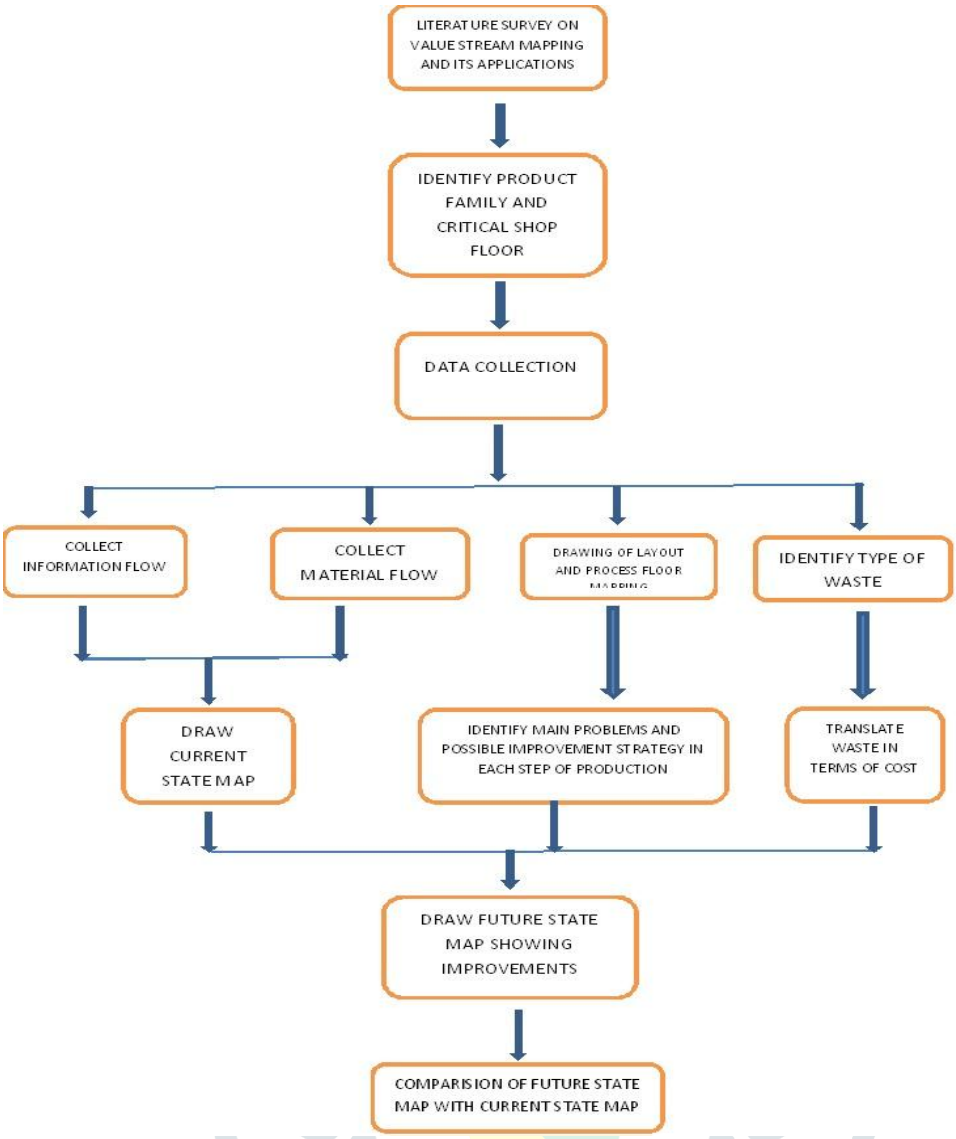


Fig 3- VSM Methodology (Detailed Steps)

LITERATURE REVIEW

The term value stream first used by Womack, Jones and Ross (1991) in their book "the machine that changed the world"[2]. And later it was described thoroughly in "Lean thinking" by Womack and jones in 1996[3]. The value is defined by the customer and created by the producer. From the point view of customer, the goal of producer must be to provide value to the customer[3]. Value is defined as the worth of what customer is paying for. Value adding activities are those activities which add some virtue of worthiness in a product for which customer wants to pay. The value stream is that which is refers only to particular (specific) parts of the firms that actually add value to the specific product or service under consideration[4]. 1n 1999,Peter Hines et.al defined VSM as a new variant of process benchmarking for the development of a supplier network around a prominent distributor of electronic, electrical and mechanical components in supply chain context. This involved mapping the activities of the firm identifying opportunities for improvements and then undertaking the firm with an improvement programme [5]. VSM provides an outline for the manufacturer to identify every single step throughout the production process. More clearly it is a visual representation of the material and information flow of a particular product family[8].

Dinesh Seth and Vaibhav Gupta have carried out the work of application of VSM in Indian perspective and to achieve productivity improvement at supplier end for an auto industry[14]. Takt time was analysed along with production output per person, reduction of WIP and finished goods inventory affecting productivity also reported. Production output per worker was improved to 17.54 from 13.95. Production Lead Time was reduced significantly from 3.215 to 0.54 days and processing time was also reduced from 15.67 to 14.13 minutes.

Rhonda R. Lummus, J.Vokurka and B.Rodeghiero have applied VSM for quality improvement by taking a case study of physician's clinic[17]. The need was to provide customers with more value and at the same time to reduce waiting time. Waiting time was NVA for patients and to manage patients with more waiting time was initially NVAs for doctors. Researchers designed a flow pattern to manage this and after implementation of that flow pattern they achieved about 25% increase in capacity without additional capital investment or hospital staff. This all was done by diverting patients as per their service priority, required time for service and allocation of right patient to right doctor so that they can achieve balanced value stream.

Markus L Stamm and Thomas Neitzert have discussed the lean methodology of value stream mapping in a manufacture to order environment considering a case study of mould making industry[21]. After the implementation of VSM in two projects they found that the relative flow velocity of material was improved from 6.0 to 2.3, which is clearly showing the reduction in waiting time which directly contributes to the improvement of the overall Lead Time of the project.

Madhubala Rauniyar studied the application of VSM in an acid handling and refining company[23]. More than 98% of all automotive batteries were recycled there. The problem arising was unbalancing in meeting customer demand because of growing demand of lead acid batteries and use of recycled lead in other products. The company wanted to implement lean methodology so that customer demand can be met by increasing throughput and capacity. The company was working presently on batch processing system with longer Lead Time and cycle time. This was thus increasing inventory and cost. To find out the solution of these problems they applied VSM to identify NVA and wastes so that they can be gradually reduced and eliminated. After studying current state map it was observed that only 53.8 hours was the processing time while it took 30.7 days for the product to be transformed from raw material to finished goods till it reaches to the end customer. The WIP was about 9.85 days. After implementation of suggestions it was observed that the Lead Time reduced to 412 hours which was 18.04 days. The processing time was reduced to 45.5 hours and it was reduced by 15.43%. it was analysed that there was a reduction of 41.23% in production Lead Time.

Bhim Singh and S.K.Sharma introduced value stream mpping as a versatile tool for lean implementation by considering an Indian case study of a manufacturing firm of small components for maintenance of railways[27]. Through the case study the existing stage of manufacturing is mapped with the help of VSM process symbols and the biggest improvement areas like excessive WIP, Lead Time and cycle time were identified. Some modifications in current state map were the suggested and then future state map was proposed. Further takt time was calculated to set the pace of production process. Later current and future state maps were compared which were showing 2.17% reduction in processing time,97.1% reduction in WIP and about 26.08% reduction in manpower requirement. This case study was showing that VSM is a powerful tool for lean implementation that allows every industry to understand and continuously improve the understanding towards lean manufacturing.

Lixia Chen has proposed application of value stream mapping based lean production system for Chinese enterprise to help them deploy lean production systematically which could make them to have an overall look at total efficiency[33]. This study was focusing on the identification and elimination of root causes of wastes, rearrange overall value stream better and to increase the competitive ability of Chinese enterprises. The result of application of VSM was showing reduction in cycle time from 1.46 hrs to 21.9 minutes, reduction in set up time from 3.2 hrs to 0.3 hrs, reduction in WIP from 67 days to 16 days and Lead Time from 67 days to 16 days.

S.Vinodh, K.R.Arvind and M.Somanaathan used the concept of value stream mapping in an Indian camshaft manufacturing organisation. The purpose of the study was to to apply VSM for enabling leanness in an Indian camshaft manufacturing organisation[37]. They chose stiffer camshaft for case study,the reason behind the selection of this product was that they were demanded more in number by the customers when compared to other products. As methodology decided already, current state map is then developed and based upon current state map; future state map is developed after some improvements in current state map. The improvements in various performance measures as a result of the case study were idle time was decreased from 19660 to 19449 minutes, total cycle time was reduced from 539 to 525 minutes, reduction of WIP inventory from 4660 to 4610 units, on time delivery improvements from 70 to 85%,reduction in defects achieved about 4% and increase in uptime was realized to 1.72%.

Duranik Tomas,Markus Stopper and Juraj Ruzbarsky described the application of value stream mapping to identify hidden reserves and avoid bottlenecks[45]. The aim behind the application of VSM was to identify any type of waste and develop a current state map. Then they described an ideal state showing only zero waste processes and finally a future state that could give answers on how to improve the production flow and efficiency, to reduce production costs and to increase flexibility. After assessing the actual situation the company was showing too many release failures and a waste production that is too high thereby exceeding delivery deadlines. Due to long delivery times the company might face losses of revenue or business by missing critical customer deadlines or paying penalties. After developing the current state into the future state Lead Time is reduced from 68.84 days to 19 days using the kanban method of lean management for the synchronisation of production and material flow. The ratio of continuous work time to value adding time indicated as the percentage of the total production time is 0.00838% which is an improvement of more than 1.5 times over the present state.

A study is described by Rumbidzayi Muvunzi,Catherine Maware,Simon Chinguwa and Mwodza Caspah to apply lean value stream mapping to reduce waste and improve productivity by taking a case study of tile manufacturing company in Zimbabwe[54]. Data for drawing the CSM was collected primarily through site visits and field work by interviewing and assistance of machine operator and field managers at shop floor level. Initially product defects were more. On an average it was 225 tile defects per day in terms of money it was $222.75 per day and $48114 per annum. At the same time company was experiencing an average of 30 minutes downtime daily which translates to 112 tiles per day. Waste was also recorded in terms of over consumption of raw material. All these problems were leading the organisation towards high waste generation and lower throughput. Some modification in current state map then done and improvements were proposed. After implementing the modifications it was found that there was a significant improvement in throughput. It was improved from 20220 tiles/month to 28350 tiles/month. The Lead Time was reduced from 3300seconds to 1260 seconds. The defect rate was improved from 245 defects/day to only 10 defects/day, which was a very significant achievement in this study.

K.Eswaramurthi and P.V.Mohanram have successfully applied VSM in inspection process by carrying out a case study[55]. The processes were observed and split into three type of activities. These activities were classified into value added, Von-Value added and essential but Von-Value added activities. By categorisation and VA/NVA analysis by cross functional team (CFT), most of the NVAs have been eliminated by shifting the inspection to production cell. After elimination of NVAs, the total times of

inspection reduced by 30% and NVA is reduced by 77%. Based on this study they suggested that improved sequence of process can help the company to reduce operations also by eliminating the unnecessary transportation and Lead Time of inspection process.

In recent year's research have been carried out on scope of value stream mapping. Mimnun Sultana and M.M.Nazrul Islam have described a case study to describe the scope of value stream mapping to initiate lean manufacturing by analysing an apparel industry of Bangladesh[56]. This apparel industry was facing high Lead Time and wastages. Current state map has been prepared for a process showing processing time 24.49 days, retention time 131.38 days and total Lead Time about 155.87 days. Improvements are then made in current state map and after analysis of future state map it was found that processing time reduced to 23.202 days, retention time reduced to 10.158 days and total Lead Time was reduced to 33.36 days. Comparing current state map and future state mapping, it can be easily seen that the value addition increases from 15.71% to 69.55% approximately and a significant reduction of no value added activity by retention time has been achieved.

Harwinder Singh and Amandeep Singh presented a paper addressing the application of lean manufacturing using value stream mapping in an auto parts manufacturing unit[57]. Using value stream concepts both current state and future state maps of the organisations shop floor scenarios have been discussed to identify sources of waste between the existing state and the proposed state of the selected organisation for improving its competitiveness. After comparison of current state and future state of the selected manufacturing unit, it has been found that here was 69.41% reduction in cycle time ,18.36% reduction in WIP and 24.56% reduction in production Lead Time for the replacement ball product. While for Weldon ball end product 51.87% reduction in cycle time, 21.51% reduction in WIP inventory, 25.88% reduction in Lead Time was noted.

Priyank Srivastava, Dinesh Khanduja and V.P.Agarwal proposed a study with purpose of developing a plan for reducing Lead Time and increasing throughput in a product manufacturing plant by using value stream mapping[60]. The plant produces rubber screening media and wear products used in mining and aggregating industry that is sold throughout the western hemisphere. The rubber manufacturer was inefficient because it produces product in batch quantities and has poor product flow due to operations being departmentalized. Because of this the manufactures was experiencing high Lead Time. A study was then carried out using value stream mapping to determine areas of potential improvement on the plant floor. A future state map was then created to suggest ways to reduce Lead Time and increase throughput. After comparison of current state and future state it was found that production Lead Time reduced from 22.5 days to 19.1 days, no of operators reduced from 7 to 6, total change over time reduced from 55 minutes to 35 minutes.

Santosh B.Dighe and Abhay Kakirde defined value stream mapping as a lean manufacturing tool for implementing lean initiatives in production process through systematic data capture and analysis[61]. This tool has been used to document current Lead Time, inventory levels and cycle times to determine the ratio of value added to total Lead Time of the product line being analysed. A case study of pump manufacturing company has been carried out and it was observed form current state map that the total Lead Time for the product was 54 days, inventory was 33 days and value added time was 0.55hrs and %VA was 0.07%.the difference between Lead Time and processing time was showing that there were a lots of non-value added activities in the process flow which was in the form of waiting of parts, moving parts from one station to another, setting up time and inventories. The process was then turned from being push to pull. Process Lead Time reduces to 36.5 days, inventory reduces to 22.4 days.

Palak P.seth, Vivek A. Deshpande and Hiren R. Kardan have studied the implementation of value stream mapping by considering ta case study of automotive industry to identify waste in terms of Von-Value added activities[62]. Current state map was then prepared to give details about 9the existing position and identify various problem areas. Future state map is prepared to show the implementation action plan. Cycle time NVA was reduced to 597 from 802 seconds and Lead Time was improved 66.7%.

Tomas Rohac and Martin Januska demonstrated value stream mapping on real case study with a view of transportation and transformation processes flowing in a company since receiving of raw materials and semi-finished products from suppliers to final delivery of finished products to a customer[67]. They suggested that through it is possible to identify the places of piling inventory, calculate a Lead Time and realize how many percentage of Lead Time are value adding and how many is not. The next step is to draw current state map of processes being carried out in the company and then go for developing the future state map by making improvements in current state map. VSM is primarily an analytical method which purpose is to identify bottlenecks and potentials for improvement at all levels of the process. In the case study the company was having total Lead Time 29636 days and total VA was 7983 seconds. All suggested improvements are then made and after comparison with current state map it was found that there was a significant improvement in total Lead Time and total VA time. The total Lead Time was reduced from 29636 to 9600 days.

Daniel Weber, C. Oberhausen and Peter Plapper introduced value stream management in –high variability production system to ensure the competitiveness of enterprise in global competition environment[68]. The goal of VSM was reduction of the high capital commitment due to large inventories in combination with an increase of productivity and a stronger adherence to delivery dates. After developing current state and future state map, the implementation of the identified measures for improvement could lead to reduction in lead time to 1.9 days from receiving of the customer order to the first partial delivery in the future state. Lead Time reduction of about 10 days in comparison with current state has been achieved. The share of value creation has been risen to 0.22 which is 5.5 times higher than the value in current state map.

SUMMARY

By studying all these case studios we can say that VSM technique is having wide scope of application, this lean tool is not limited to only one organisation or industry. A number of objectives can be achieved by using VSM .the objectives could be reduction in Lead Time and cycle time, reduction in WIP, reduction in wastes and NVAs, identification of waste and NVAs, improvement in Vas, satisfying customer requirements, managing supply chain etc. VSM is a world class manufacturing tool that

can be used to achieve all objectives stated above. Companies are experiencing a heavy pressure due to globalization hence they cannot afford to operate with waste in their process. The prime focus of VSM should be to identify and eliminate waste and waste associated activities because it has been proven by previous research and literature that most of the problems in production environment are being birthed by all categories of waste.

CONCLUSION

In this paper the available literature on VSM has been categorised yearly focusing on their aim and finding after implementation of VSM. Based on the literature we can say that VSM also works for the integration of man, machine and material along with methods. VSM should not be end with one improvement; it should be continued with continuous improvements.

REFERENCES

1. Ohno, T. (1988). *Toyota production system: Beyond large-scale production.* Cambridge, MA: Productivity Press
2. *Womack, P.J., Jones, TD., Roos, D.* (1991). *The machine that changed the world: The story of lean production.* New York, NY: Harper Perennial
3. Womack, J., & Jones, D. (1996). *Lean thinking: Banish waste and create wealth in your corporation.* New York, NY: Simon & Schuster
4. Hines P, Rich N.(1997) "The seven value stream mapping tools" *International Journal Operations and production Management , pp.*46–64
5. Hines P, Rich N and Esain Ann. (1999) "*Value stream mapping – a distribution industry application"* Benchmarking International Journal, Vol. 6 No. 1, pp. 60-77
6. Lovelle,J. (2001). Mapping the value stream, lIE Solutions..
7. Rother, M. & Shook, 1. (2002). *Value Stream mapping workshop.* Brookline, MA: Lean Enterprise Institute
8. Tapp.ing, D., Luyster, T., & Shuker, T. (2002). *Value stream management: Eight steps to planning, mapping, and sustaining lean improvements.* New York, NY: Productivity Press.
9. Peter Hines, Riccardo Silvi, Monica Bartolini(2002) *"Lean Profit potential"* 1-64,
10. Tapp.ing, D., & Shuker, T. (2003). *Value stream management/or the lean office: Eight steps to planning, mapping, and sustaining lean improvements in administrative areas.* New York, NY: Productivity Press
11. Womack, J.P. and Jones, D.T. (2003). *Lean Thinking*. 1st Free Press ed., New York: Free Press, pp.16- 26
12. Hugh L. McManus, September (2005) *Product Development Value Stream Mapping (PDVSM) Manual 1.0* Report for lean Aerospace Initiative Centre for Technology, Policy and Industrial Development
13. Carreira, B. (2005). *Lean manufacturing that works: Powerful tools for dramatically reducing waste and maximizing profits.* New York: Amacom
14. Seth, D. and Gupta, V. (2005). *Application of Value Stream Mapping for Lean operations and cycle time reduction: an Indian case study*, Production Planning & Control, Vol. 16 No. 1, pp. 44-59
15. Peter Burcher, (2005) *Lean Viewed As a Philosophy.*
16. Wysk, AR., Torres, MJ. (2006). *Improving production with lean thinking. Hoboken*, New Jersey: John Wiley & Sons, Inc.
17. Lummus, R.R., Vokurka, J. and Rodeghiero, B. (2006). *Improving quality through Value Stream Mapping: a case study of a physician's clinic*, Total Quality Management, Vol. 17 No. 8, pp. 1063-75
18. Bill Ray, Paul Ripley, Doug Neal, January (2006) *Lean Manufacturing – A Systematic App.roach to Improving Productivity in the Precast Concrete Industry* Brock C
19. Abdulmalek, F.A. and Rajgopal, J. (2007). *Analyzing the benefits of Lean Manufacturing and Value Stream Mapping via simulation: a process sector case study*, International Journal of Production Economics, Vol. 107, pp. 223-36
20. Liker, J.K. and Meier, D. (2007). *The Toyota Way*, Field Book, Tata McGraw-Hill Edition, New Delhi, pp. 41.
21. Stamn L. Markus and Neitzert T.(2007). *Value stream mapping in am manufacturing to order small and medium enterprises*, School of engineering, AUT university
22. Value stream mapping symbols.(Retrieved January 29,2007) from *http://www.strategosinc.com/value-stream-mapping-3.htm*
23. Madhubala Rauniyar (2007)"*Value Stream Mapping at XYZ Company*"
24. I.S., Laburu, C.O. and Vila, R.C. (2008). *An evaluation of the Value Stream Mapping tool*, Business Process Management, Vol. 14 No. 1, pp. 39-52.
25. Seth, D., Seth, N. and Goel, D. (2008). *Application of Value Stream Mapping for minimization of wastes in the processing side of supp.ly chain of cotton seed oil industry in Indian context*, Journal of Manufacturing Technology and Management, Vol. 16 No. 4, pp. 529-50
26. Ramesh, K.V. Sreenivasa Prasad, T.R. Srinivas (2008) " *Implementation of a Lean Model for Carrying out Value Stream Mapping in a Manufacturing Industry*" Journal of Industrial and Systems Engineering Vol. 2, No. 3, pp. 180-196
27. Bhim Singh and S.K. Sharma (2009)"*Value stream mapping as a versatile tool for lean implementation: an Indian case study of a manufacturing firm*" Emerald Group publishing limited ISSN 1368-3047 Vol.13 No.3
28. Hines, P., Rich, N. and Esain, A. (1999).*Introduction to Lean* .Available from: http://www.mamtc.com/lean/intro_intro.asp *(Accessed 10 May 2010)*

29. McBride, D. *The 7 Manufacturing Wastes*. Available from: http://www.emsstrategies.com/dm090203article2.html (Accessed 05 May 2010)
30. Ulf K. Teichgraber, Maximilian de Bucourt(2010) "*Applying value stream mapping techniques to eliminate non-value-added waste for the procurement of endovascular stents"* European Journal of Radiology 81 e47– e52.
31. Lucas Simmons, Robbie Holt, Glenn Dennis (2010)"*Lean Implementation in a Low Volume Manufacturing Environment: a Case Study*", Proceeding of the 2010 industrial engineering research conference
32. Nordin, Baba MdDeros and Dzuraidah Abd Wahab (2010) *"A Survey on Lean Manufacturing Implementation in Malaysian Automotive industry*" International Journal of Innovation, Management and Technology, Vol. 1, No. 4, October 2010
33. Lixia Chen, Bo Meng (2010) "*The Application of Value Stream Mapping Based Lean Production System*" International Journal of Business and Management Vol. 5, No. 6, pp. 203-209
34. S. P. Vendan , K. Sakthidhasan (2010) "*Reduction of Wastages in Motor Manufacturing Industry*" Jordan Journal of Mechanical and Industrial Engineering Volume 4, Number 5, pp. 579-590
35. Abuthakeer ,P.V. Mohanram, G. Mohan Kumar (2010) *"Activity Based Costing Value Stream Mapping*" International Journal of Lean Thinking Volume 1, Issue 2, pp. 52-64
36. V. Ramesh1, K.V. Sreenivasa Prasad, T.R. Srinivas (2010) "*Implementation of a Lean Model for Carrying out Value Stream Mapping in a Manufacturing Industry"*
37. Vinodh S.,Arvind,K.R. and Somanathan M.(2010) "*Application of Value Stream Mapping in an Indian camshaft manufacturing organisation"* Journal of Manufacturing Technology Management Volume 21,No.7,pp. 888-900.
38. Abhinaya Kasojo, (2011) *Evaluating Value Stream Mapping Software Testing Context In Automotive Domain : A Case Study*.
39. Bhim Singh, Suresh K. Garg, and Surrender K. Sharma (2011) "*Value stream mapping: literature review and implications for Indian industry*" International Journal Advanced Manufacturing Technology 53 pp. 799–809
40. William M. Goriwondo, Samson Mhlanga, Alphonce Marecha (2011)"*Use of the value stream mapping tool for waste reduction in manufacturing Case study for bread manufacturing in Zimbabwe*" International Conference on Industrial Engineering and Operations Management Kuala Lumpur, Malaysia 2011 236-241
41. K. P. Paranitharan, M. ShabeenaBegam, S. SyathAbuthakeer, M. V. Subha (2011)"*Redesigning an Automotive Assembly Line through Lean Strategy"* International Journal of Lean Thinking Volume 2, Issue 2
42. Y O. Ram Mohan Rao, Dr. K Venkata Subbaiah, Dr. K Narayana Rao, T Srinivasa Rao (2011), "*Enhancing Productivity of hot metal in Blast furnace -A case study in an Integrated Steel Plant*".International Journal of Engineering Science and Technology (IJEST). Pp. 3518-3525
43. Dimple Khatri, Pardeep Dhull, Rajender Kumar, Vinod Dhull (2011), "*Reduce the Work In Progress by using Value Stream Mapping (A Lean Manufacturing Key Tool)*" ISSN: 2249 – 6564. International Journal of Mechanical Engineering Applications Research, pp. 91-99
44. D. Rajenthira Kumar, P.V. Mohanram, S.G. Harikarthik (2011) "*Process Cycle Efficiency Improvement Through Lean: A Case Study"* International Journal of Lean Thinking Volume 2, Issue 1, pp. 47-58
45. Tomas Duranik,Stopper M., and Ruzbarsky J. (2011) "*Applying value stream mapping to identify hidden reserves and avoid bottlenecks"* Annals of DAAAM & proceedings of DAAAM symposium,Vol. 22,No. 1
46. Jorgen Frohm, (2011) "*Levels of Automation in Production Systems"*
47. R.M. Belokar, Vikas Kumar, Sandeep Singh Kharb (2012)"*An Application of Value Stream Mapping In Automotive Industry: A Case Study*" International Journal of Innovative Technology and Exploring Engineering Volume-1, Issue-2,
48. Silva, S.K.P.N(2012) "*Applicability of value stream mapping in the apparel industry in Sri Lanka*" International journal of lean thinking Volume 3
49. Jirapat Wanitwattanakosol and Apichat Sopadang, (2012) *Lean Manufacturing Systems in Small and Medium Enterprises : A Framework for Lean Tools Integration*
50. Rahani AR and Muhammad Al-Ashraf (2012) *Production Flow Analysis through Value Stream Mapping : A Lean Manufacturing Process Case Study*
51. Sanjay Bhasin,Saurabh Kerhalkar and K.N. Nandurkar (2012) *Development of VSM Implementation Procedure for Prefabrication Shop Through Case Study Approach*
52. Sharma Neha, Matharou Gurpreet Singh, Kaur Simran and Gupta Pramod, (2013) *Lean Manufacturing Tools and Techniques in Process Industry*
53. *Sri Lanka* Simon Withers, Jose Arturo Garza-Reyes, Vikas Kumar, Luis Rocha-Lona, (2013) *A Case Study Improvement of a Testing Process by Combining Lean Management, Industrial Engineering and Automation Methods* Vol. 3, no 3
54. Muvunzi R.,Maware C.,Chinguwa S.,Caspah M.(2013) "*Application of lean value stream mapping to reduce waste and improve productivity- A case of Tile manufacturing company in Zimbabwe"* international journal of application or innovation in engineering & management, Vol.2,Issue 7.
55. Eswaramurthi K. and Mohanram P.V. (2013) "*Value and Non Value added activities analysis of an inspection process"* international journal of engineering research & technology,Vol.2 issue 2.
56. Sultana M. and Islam Nazrul M.M. (2013) "*scope of value stream mapping to initiate lean manufacturing:an analysis in the apparel industry of Bangladesh"* international journal of lean thinking Vol.4,Issue 1.

57. Singh Harwinder and Singh Amandeep(2013) " *application of lean manufacturing using value stream mapping in an auto parts manufacturing industry"* Journal of advances of management research,Vol.10,No.1,pp. 72-84.
58. S.K.P.N (2013), *Applicability If Value Stream Mapping (VSM) In the Apparel Industry In*, 2013. Thesis no : MSE-2011:61
59. K. M. Khalid, Ahmad Y. B. Hashim, and Mohd R. Salleh (2014) "*On Value Stream Mapping and Its Industrial Significance*" Journal of Industrial and Intelligent information Vol. 2, No. 2,
60. Srivastava Priyank, Khanduja D. and Agarwal P.V. (2014) "*Value stream mapping-powerful tool for lean manufacturing"* Internation journal of advanced technology in engineering and science, Vol.2,Issue 1.
61. Dighe B. Santosh and Kakirde Abhay(2014)"*Lean manufacturing implementation using value stream mapping- a case study of pumps manufacturing company"* International Journal of science and research.
62. Palak P Sheth, Vivek A.Deshpande , Hiren R.Kardani (2014) *" Value Stream Mapping : A Case Study of Automotive Industry*" International Journal of research in Engineering and technology eISSN :2319-1163 / pISSN: 2321-7308
63. K. Venkataraman, B.VijayaRamnath, V.Muthu Kumar, C.Elanchezhian(2014) **"***Application of Value Stream Mapping for Reduction of Cycle Time in a Machining Process*" 3rd international conference of on materials processing characterization(ICMPC)
64. Dzanya, M. M. (2015). *Value stream mapping in glide manufacturing: A case study of Insti-Tools in Zimbabwe*. International journal of science,technology and society, V3, 6-10
65. Gunaki, P. T. (2015*). Productivity improvement by Value Stream Mapping in Die Casting Industry*. Journal of emerging technologies and innovative research V2, 2049-2064.
66. Morlock, F. M. (2015). "*Service value stream mapping in Industrial Product Service System Performance Management"* 7th industrial product service system conference-PSS industry transformation for sustainability and business (pp. 457-461). Elsevier
67. Rohac Tomas and Januska Martin.(2015) "*Value stream mapping demonstration on rel case study"*25th DAAAM International symposioum on intelligent manufacturing and automation,Elsevier Procedia engineering 100,pp. 520-529.
68. Oberhausen, C. Plapper Peter (2015). "*Value stream management in lean mnaufacturing laboratory*". The 5th conference on learning factories,pp.144-149. Elsevier.
69. Pandya, H. S. (2015). *lean manufacturing implementation using value stream mapping in an automotive industry*. international journal of advance engineering and research V2, pp. 812-822.
70. Paranitharan, P. B. (2015). *Application of value stream mapping in an Brass lamp manufacturing organisation*. international journal of app.lied engineering research V10, pp. 28203-28218
71. Pathak, D. D. (2014). *value stream mapping methodology for lead time reduction*. journal of emerging technologies and innovative research V1, pp. 493-498
72. Vasmi, N. S. (2014*). Lean manufacturing implementation using value stream mapping as a tool*. international journal of lean six sigma V5, pp. 89-116
73. Rohac, T. J. (2015). *value stream mapping on real case study*. 25th DAAAM international symposium on intelligent manufacturing and automation (pp. 520-529). Elsevier
74. Tyagi, A. Y. (2015). *Value stream mapping to reduce the lead time of a product development process. international journal of production economics, pp. 202-212*
75. Vijaykumar, S. K. (2015). *Pull flow manufacturing: A case study of Automotive Industry*. Internation journal on concurrent app.lied research in engineering and management, V1(1), pp. 108-112
76. Weber, D. P. (2015). *Value stream management in high variability production systems*. Inetrnational journal of indistrial engineering V2, pp. 1-4.