Application of Value Stream Mapping to Reduce the Production Lead Time in Valve Manufacturing Process: A Case Study

Sreehari Nair[1] Dr. Shivakumar S[2] Roopa Navalli[3]
[1]PG Student [2]Professor [3]Assistant Professor
[1,2,3]Department of Mechanical Engineering
[1,2,3]KLS Gogte Institute of Technology, Belgaum, Karnataka-590008, India

Abstract— Lean approach in firms, particularly in manufacturing sectors, are increasingly applied to reduce the non-value adding time and improve productivity. Value stream mapping is one of the efficient tools of a lean approach, which helps in not only in mapping the process but identifying the criticality present in the process under investigation. The present work focuses on implementing the value stream mapping tool in the valve manufacturing process of an Indian manufacturing unit. The current state map drawn was for the process based on the collected data. The future state map was proposed and implemented. The result indicated an improvement of the overall process quantified by an increase of value-added time by 3.26% and a reduction in production lead time by 41.98%.

Keywords: Cycle Time, Industrial Engineering, Lead-Time, Lean Manufacturing, Productivity Improvement, Value Stream Mapping

Abbreviations: GV, Globe Valve; BSGV, Bellow Seal Globe Valve; VSM, Value Stream Mapping; CSM, Current State Map; FSM, Future State Map; C/T, Cycle Time; C/O, Changeover Time

I. INTRODUCTION

The lean approach is an initiative taken by several businesses over the world to remain competitive in the continuously increasing global market [1]. The reason for the increasing trend being the capability of the lean approach to improve productivity using the least amount of non-value adding activities and the economic advantage [2].The urge of firms to adopt lean approaches has been creating interest in researchers and practitioners to explore in detail the tools and techniques involved in its successful implementation, particularly in India [3]. Value stream mapping (VSM) is one such tool of lean manufacturing that facilitates not only the mapping of a process but also in identifying the main criticalities involved in it [4]. In other words, VSM gives a complete pictographic representation of customer value addition in the process, concerning the production flow from raw material to the customer and the information flow from concept to launch [5]. Viewing at the ease of application and potential of error detection, VSM has been applied by several researchers over the globe, in their work to investigate the critical element(s) present in the examined system. For example, Lacerda et al. [6] applied VSM in the production process of parts for four major automotive companies. The implementation helped not just in reducing the cycle time and inventory level but also in eliminating a bottleneck operation.

Nallusamy [7] implemented the value stream mapping technique in a gear manufacturing industry to investigate the critical elements in the gear shaft manufacturing process. As a result of the implementation, the manufacturing lead time reduced by 3 mins per shaft, which further improved the customer demand meeting time. Helleno et al. [8] analyzed the effectiveness of the value stream mapping tool by implementing it in various types of manufacturing sectors in Brazil. The results indicated VSM to be an efficient tool for assessing the sustainability of the manufacturing processes. Ishak et al. [9] implemented value stream mapping in a composite repair shop, which helped the organization to identify the critical elements that improved labor productivity. Bhat et al.[10] implemented the VSM tool at a pharma process in a Malaysian Insulin manufacturing company. The implementation helped to reduce the overall production lead time by 60.29%.

The practical implementation of value stream mapping by Cerfolio et al. [11] in the New York City Academic Hospital, helped to eliminate the non-value added operating procedures and turnovers and improve the overall workflow. An implementation of VSM helped Vilventhan et al. [12] to identify, assess and eliminate the material waste in a construction industry. Rehman et al. [13] improved the total productivity factor by 11.45% by implementing VSM in a Saudi Arabian manufacturing Unit. Singh & Singh [14] implemented the VSM tool in an Indian automotive industry to investigate the automotive suspension and fastening components section. The study resulted in reducing the cycle time and production lead time by 87.59 and 95.41%, respectively. VSM tool when implemented in a Chinese agricultural plant by Liu et al. [15], resulted in optimizing the cycle time for each process and improving the process efficiency. Concerning the successful lean implementation, nearly about 25.6% of the researchers utilized the VSM tool, considering it to be the most appropriate tool for identifying the criticality or gap [16].

Considering the effectiveness and efficiency of the VSM tool, as evident from the literature, the present work aims to implement the same to an Indian manufacturing unit. The case presented deals with the detailed study of a valve manufacturing process in the selected unit using the value stream mapping technique. The current and future state maps are drawn in the article using the E-Draw 6.1 software package. Further sections deal with the in-detail methodology, obtained results, and provided a solution to the identified problem.

II. MATERIAL AND METHOD

Globe valves (GV) used are in the situation where there is a need for throttling of the fluid, wherein the flow regulation achieved is through the handwheel attached to it [17]. Fig 1 represents a globe valve in its front view. It is called so because of its outer shape[18]. GVs are much expensive than other valves for a given coefficient of flow [19]. Therefore, the manufacturing process of GV is selected for the present study; this component contributes to a significant portion of the firm's profit. The part family selected is bellow seal globe valve (BSGV) of size 50 and class 150. The company selected for the investigation purpose works with just one shift per day. Including the two breaks, the available working time is 480 min. (8 h shift). There are two breaks of 10 min. each and a lunch break of 20 min. given to the worker community.

Fig. 1: Front view of a simple globe valve [20].

Considering the manufacturing process, Fig 2 represents the operations involved in their sequence.

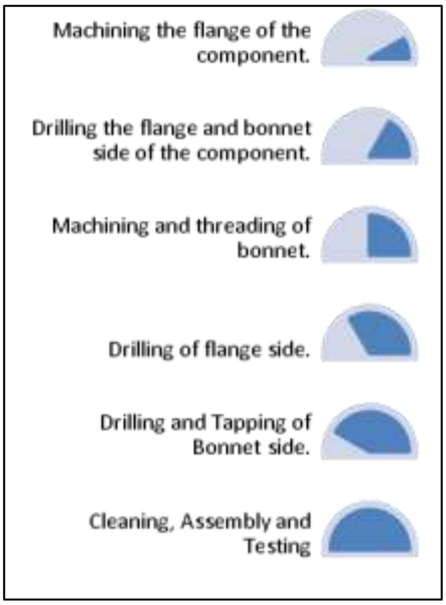

Fig. 2: The sequence of operations involved in the making of bellow seal globe valve 50/150.

The first step involved in value stream mapping is the making of the current state map. The current state map developed is based on the data collected in detail from the manufacturing process line for each operation. The selected component, BSGV 50/150, follows a weekly customer demand of 25 units per order. The raw material for the making of component received is in cast form which is received, inspected, and taken to the machining section.

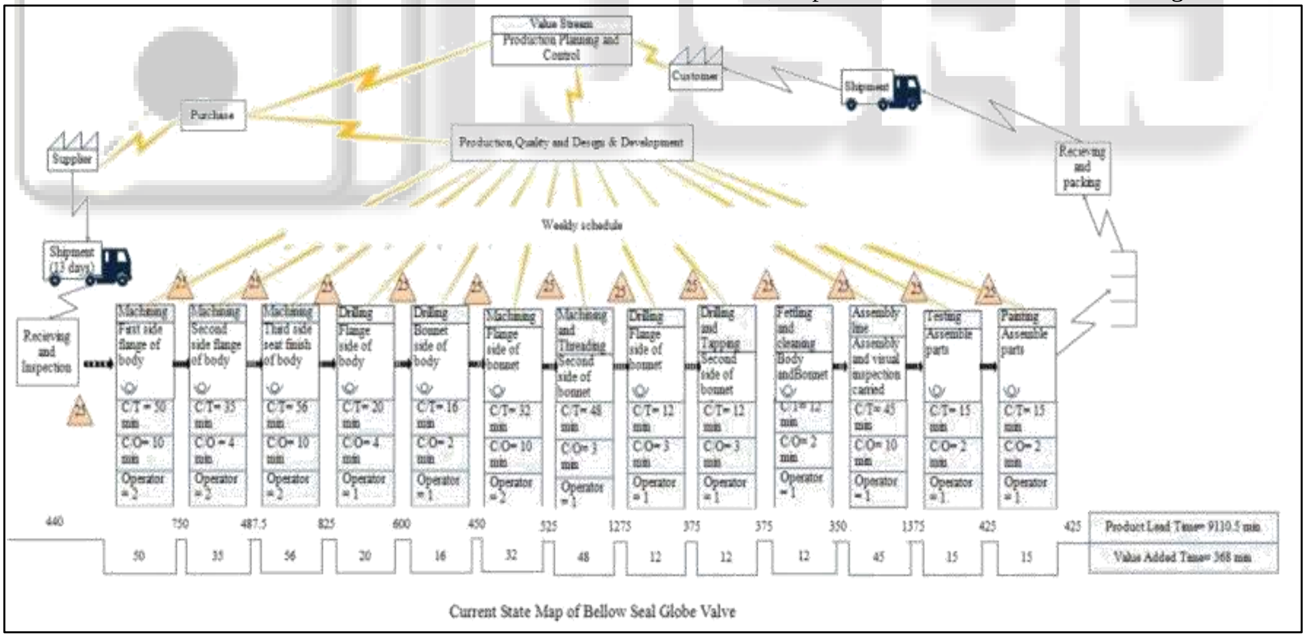

Fig. 3: The current state map created for the manufacturing process line of BSGV 50/150.

Firstly, one side of the flange is machined, requiring 50 min of machining time. The change over time involving initial setups like clamping and tool setting consumes 10 min. The machined part is moved to the next machine wherein the second side of the flange is machined. The cycle time (C/T) and the changeover time (C/O) for the 2nd process are 35 and 4 min respectively. The third machining process is to provide a seat finish to the component which has a C/T and C/O of 56 and 10 min respectively. Drilling operations follow machining. The fourth operation is to drill at the flange portion and the fifth is to drill the bonnet side of the component. The C/T and C/O for 4th operation are 20 and 4 min respectively whereas the C/T and C/O for 5th operation are 16 and 2 min respectively. The 6th operation is the machining of the bonnet side of the flange which takes about 32 min. of C/T and 10 min. of C/O. The 7th operation involves machining and threading of the second side of the bonnet, having a C/T and C/O of 48 and 3 min, respectively. 8th and 9th operations involve drilling and tapping at the bonnet end respectively. The C/T and C/O for each of the operations is 12 and 3 min respectively. The drilling is followed by the fettling and cleaning process, consuming 12 min for each part and a C/O of 4 min.

The assembly and visual inspection stage consumes 45 min for each part and involves a change over time of 10 min. The last operation is testing which has a C/T of 15 min. and a C/O of 2 min. Figure 3 provides a complete picture of the overall information and material flow concerning the BFGV 50/150 component through a current state map (CSM). Besides the basic data discussed in the section, the CSM provides additional information such as the observed lead time for each operation, the material flow system type (push system), the transportation mode and the number of operators for each operation.

III. Results and Discussion

Inventory holding time between each process calculated. The uptime for all the operations in the process was nearly 100% and there were no defective parts produced. Considering all the recorded facts the total lead time for the process line is calculated. Inventory hold time is given by sum of the product of cycle time, inventory plus changeover time and divided by number of operators.

Product lead time is given by the sum of intial hold time, cycle time, changeover time and holding time.

The total lead time is determined to be 9110.5 minutes, and the value-added time concerning the component manufacturing (cycle time) is just 368 minutes. The lead time when converted to the number of weeks, gives a value of 3.451. It is evident from the current state map that there is a delay of 2.451 weeks in meeting the customer demand for 25 components. Thus, further analysis is required to identify the criticality. As the first step to critical analysis. TAKT time is ratio of work time available and customer demand i.e, 440/5 is equal to 88min

Fig 4 represents the bar graph for the processing time of each process with a limiting line of TAKT time. The figure indicates that there is no process in the manufacturing line which crosses the TAKT timeline. Thus, it could be inferred that none of the processes are overutilized. The observation is also that there are a few underutilized processes.

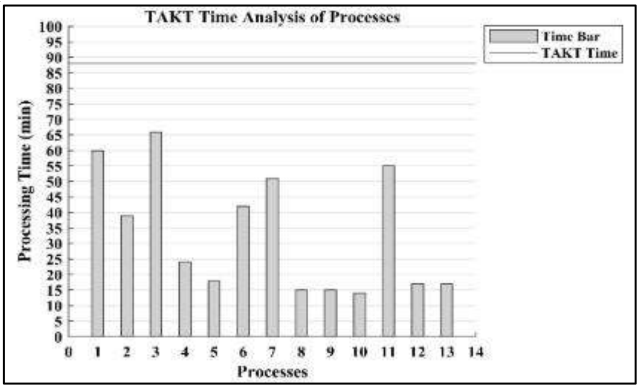

Fig. 4: TAKT time analysis of current state operations.

Thus, further analysis was done to check for the possibility of combining the processes. GEMBA (shop floor) KAIZEN was implemented. The result of kaizen (small change for good reason) is as follows:

– A small storage section is made for storing the received and inspected raw material, rather than stocking it near the machine section. The initial stock holding time prior to the first machine is eliminated.
– Instead of pushing the whole 25 pieces, only five pieces are pushed between the machines at a given instant of time. This small number of pushed batch size reduces the inventory holding time between the processes to a great extent.
– Process 4 and 5 from CSM pertaining to drilling of flange and bonnet are combined, as both were underutilized operations.
– The process of fettling was combined with three different processes and thus was eliminated as a sole process.
– The first-In-First-Out rule is applied for the movement of the component from one process to another.
– A storage section is made at the end of the last operation for the safe storage of tested components. The storage, also known as a supermarket in lean language, eliminates the stocking of components near the testing zone.
– The operators were rearranged as per the requirement of operations.

Fig 5 represents the proposed and implemented the future state map. The total lead time is determined to be 1899.3 minutes and the value-added time concerning the component manufacturing (cycle time) is just 380 minutes. The lead time when converted to a number of weeks, gives a value of nearly 4.32 days which is lesser than a week. The implementation of the FSM helped to reduce the total lead time of the production by 79.15% and improved the value-added time by 3.26%. Special care is taken that the operators are not fired but just rearranged. In simple words, value stream mapping helped in identifying the critical issues, the depth and breadth of the problem, facilitated the right secondary lean (GEMBA KAIZEN) tool usage. The overall work helped in achieving an efficient and effective manufacturing process line for the BSGV 50/150 production in the selected Indian valve manufacturing unit.

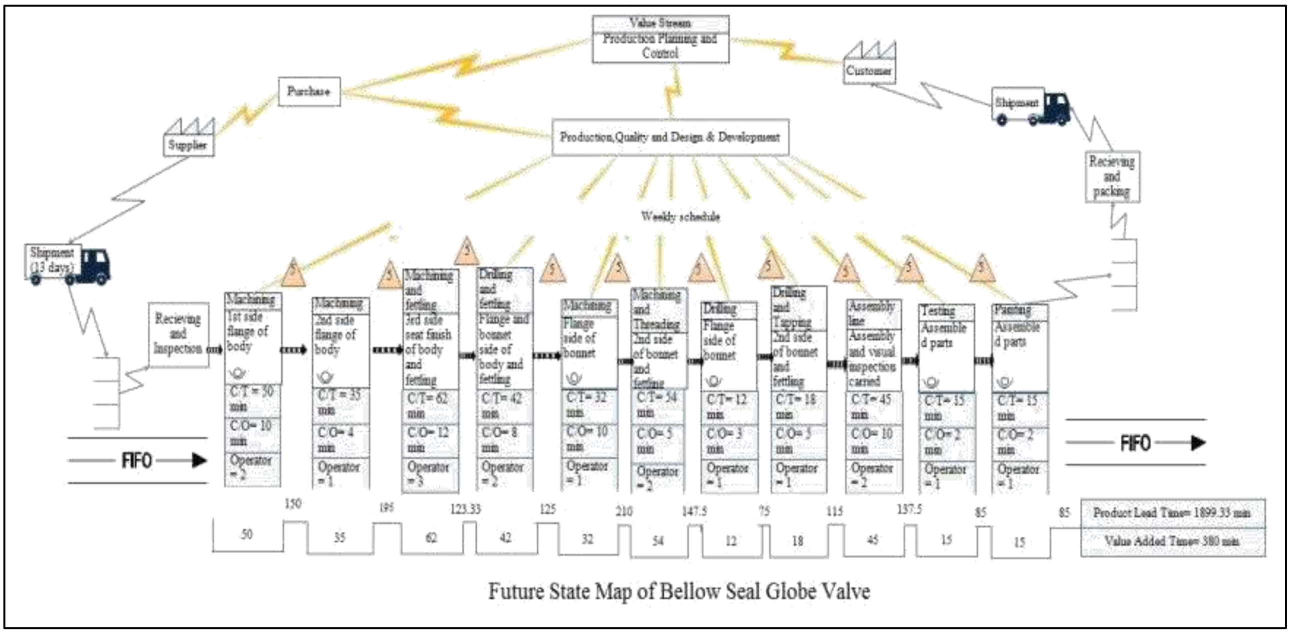

Fig. 5: The future state map created for the manufacturing process line of BSGV 50/150.

IV. Conclusion

The present work focuses on investigating the implementation of the lean approach in an Indian valve manufacturing unit. The study comprises implementing value stream mapping for identifying the critical issues in the process line of one of the most profitable products in the selected firm. GEMBA KAIZEN is used to improve the process further. The objective of the work was to reduce the overall production lead time as in the current state; the lead time was overshooting the demand meeting time. The implementation reduced the overall lead time by 79.15% and improved the value-added time by 3.26%. Besides, the work also focused on not laying-off the workers but rearranging them to get the optimum results.

Acknowledgements

The authors would like to thank the supervisors, operators, and management of the manufacturing firm for allowing us to conduct the work, and implementing the improvement suggested.

Conflict of Interest: There exists NO conflict of interest between the authors. Also, the work received NO funding from any private/government/non-government agencies.

References

[1] F. A. Abdulmalek and J. Rajgopal, “Analyzing the benefits of lean manufacturing and value stream mapping via simulation: A process sector case study,” International Journal of Production Economics, vol. 107, no. 1, pp. 223–236, May 2007, doi: 10.1016/j.ijpe.2006.09.009.

[2] R. Bhat and R. Shetty, “Investigation of Lean Tools to Enhance Productivity in Manufacturing Sector,” Proceedings of 2nd International Conference on Emerging Trends in Engineering and Management, vol. 3, no. 3, pp. 116–120, 2013.

[3] D. Seth and V. Gupta, “Application of value stream mapping for lean operations and cycle time reduction: An Indian case study,” Production Planning and Control, vol. 16, no. 1, pp. 44–59, Jan. 2005, doi: 10.1080/09537280512331325281.

[4] M. Braglia, G. Carmignani, and F. Zammori, “A new value stream mapping approach for complex production systems,” International Journal of Production Research, vol. 44, no. 18–19, pp. 3929–3952, Sep. 2006, doi: 10.1080/00207540600690545.

[5] R. R. Bhat and S. Shivakumar, “Improving the Productivity using Value Stream Mapping and Kanban Approach,” International Journal of Scientific & Engineering Research, vol. 2, no. 8, pp. 1–5, 2011.

[6] A. P. Lacerda, A. R. Xambre, and H. M. Alvelos, “Applying Value Stream Mapping to eliminate waste: A case study of an original equipment manufacturer for the automotive industry,” International Journal of Production Research, vol. 54, no. 6, pp. 1708–1720, Mar. 2016, doi: 10.1080/00207543.2015.1055349.

[7] S. Nallusamy, “Lean manufacturing implementation in a gear shaft manufacturing company using Value Stream Mapping,” International Journal of Engineering Research in Africa, vol. 21, pp. 231–237, Dec. 2016, doi: 10.4028/www.scientific.net/JERA.21.231.

[8] A. L. Helleno, A. J. I. de Moraes, A. T. Simon, and A. L. Helleno, “Integrating sustainability indicators and Lean Manufacturing to assess manufacturing processes: Application case studies in Brazilian industry,” Journal of Cleaner Production, vol. 153, pp. 405–416, Jun. 2017, doi: 10.1016/j.jclepro.2016.12.072.

[9] F. A. Ishak, M. K. Johari, and R. Dolah, “A case study of LEAN application for shortest lead time in composite repair shop,” International Journal of Engineering and Technology(UAE), vol. 7, no. 4, pp. 112–119, Oct. 2018, doi: 10.14419/ijet.v7i4.13.21341.

[10] R. Bhat, N. Mohan, M. Naidu, and S. Shivamurthy, “Reducing the Production Lead Time of an Industry

Using Value Stream Mapping Integrated with Kaizen," vol. 7, pp. 21–23, 2018.
[11] R. J. Cerfolio et al., "Improving Operating Room Turnover Time in a New York City Academic Hospital via Lean," The Annals of Thoracic Surgery, vol. 107, no. 4, pp. 1011–1016, Apr. 2019, doi: 10.1016/j.athoracsur.2018.11.071.
[12] A. Vilventhan, V. Ram, and S. Sugumaran, "Value stream mapping for identification and assessment of material waste in construction: A case study," Waste Management & Research, vol. 37, no. 8, pp. 815–825, Aug. 2019, doi: 10.1177/0734242X19855429.
[13] A. Ur Rehman, Y. S. Usmani, U. Umer, and M. Alkahtani, "Lean Approach to Enhance Manufacturing Productivity: A Case Study of Saudi Arabian Factory," Arabian Journal for Science and Engineering, vol. 45, no. 3, pp. 2263–2280, Mar. 2020, doi: 10.1007/s13369-019-04277-9.
[14] J. Singh and H. Singh, "Application of lean manufacturing in automotive manufacturing unit," International Journal of Lean Six Sigma, vol. 11, no. 1, pp. 171–210, Jan. 2020, doi: 10.1108/IJLSS-06-2018-0060.
[15] Q. Liu, H. Yang, and Y. Xin, "Applying value stream mapping in an unbalanced production line: A case study of a Chinese food processing enterprise," Quality Engineering, vol. 32, no. 1, pp. 111–123, Jan. 2020, doi: 10.1080/08982112.2019.1637526.
[16] M. Z. Rafique, M. N. Ab Rahman, N. Saibani, and N. Arsad, "A systematic review of lean implementation approaches: a proposed technology combined lean implementation framework," Total Quality Management & Business Excellence, vol. 30, no. 3–4, pp. 386–421, Feb. 2019, doi: 10.1080/14783363.2017.1308818.
[17] R. A. Parisher and R. A. Rhea, "Pipe Drafting and Design (Third Edition)," in Pipe Drafting and Design, Elsevier, 2012, pp. 79–111
[18] E. Shashi Menon, "Meters and Valves," in Transmission Pipeline Calculations and Simulations Manual, Elsevier, 2015, pp. 431–471.
[19] P. Bajpai, "Hydraulics," in Biermann's Handbook of Pulp and Paper, Elsevier, 2018, pp. 455–482.
[20] H. Smith, "Globe Valve," The Alloy Valve Stockist's photo gallery, 2009. [Online]. Available: https://upload.wikimedia.org/wikipedia/commons/c/c5/Globe-valve.JPG.

