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Practical Approach of Value Stream Mapping to Improve Processes in an Automotive Industry

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Abstract: The industrial sector requires applying methodologies that contribute to continuous improvement and cost reduction within organizations. The present work shows the results and lessons learned from three projects carried out in a local automotive industry. The Value Stream Map tool is used to identify the activities that add value to the product and to detect the opportunity areas throughout the value chain. The objective is to implement solutions that improve central process flow to meet customer demand. Lean tools such as SMED, Kanban and line balancing among others, were used as support for the project's development. The first step was to define the family of products for each project, next, the current state map of the production chain was determined as well as the metrics necessary for the analysis. After that, the map of the future state was defined, and finally, an improvement implementation plan was described. The approach used for each project combined with used methodologies was highly significant to maximize the achieved benefits. At the end of implementing these projects, the results obtained show reduction up to 50% in lead time for specific manufacturing processes, reduction of curing times up to 58%, elimination of inventories in process, development of tooling designs, automation in some areas of the process, takt time and waiting time reduction.

Keywords: Value Stream Map, Lead Time, Process

1. Introduction

Due to the great competitiveness that world-class companies face every day, organizations are in need of analyzing their manufacturing processes and implementing improvements, in order to achieve maximum efficiency of resources, increase productivity and reduce costs. In the present work, the application of the Value Stream Map (VSM) tool is presented to analyze value flow along with the manufacturing process. The main objective of applying the aforementioned tool, is to identify opportunity areas and to establish improvement strategies in an automotive company, leader in product development and design, located in the northern region of the country.

Value Stream Mapping (VSM) is a process improvement lean technique published by Rother and Shook (2003). Value stream is defined as all the actions (both value added and non-value added) required to bring a product through the main flows essential to every product. This tool has its roots in Lean Manufacturing, a set of principles used to enable manufacture of goods with fewer resources and elimination of waste. Ohno (1988) is recognized as the creator of Toyota Production System (TPS) or Lean Manufacturing, his book "Toyota Production System: beyond large-scale production" describes the seven wastes or seven mudas which are: transport, inventory, motion, waiting, over-processing, overproduction, defects, and additionally the most important is non-used talent (Calva, 2011) added by Womack and Jones (1997), who developed the term lean thinking. They proposed the five lean principles which are: specify value, identify the value stream and eliminate waste, make the value flow, let the customer pull, and pursue perfection. Value Stream Mapping is a pencil and paper tool that helps to see and understand the flow of material and information as a product makes its way through the value stream. Value stream mapping is simple: follow a product's production path from customer to supplier, and carefully draw a visual representation of every process in the material and information flow. Mapping help to see the sources of waste in process value stream, this provides the information needed to design and introduce a lean value stream called Future State drawing, which is focused on flow with a vision of an ideal or at least an improved state. Rother and Shook (2003).

VSM has been applied mainly for lead time reduction with the perspective of increasing process efficiency. The implementation level of this tool in the manufacturing sector is significantly higher when compared to other sectors. Although many of the tools and techniques of lean thinking have been widely used in discrete manufacturing, there are applications for continuous production also (Abdulmalek and Rajgopal, 2007). VSM has been implemented not only in manufacturing sectors, but also in health care, construction, product development and service sectors with fundamental differences (Shou et al., 2017). There are interesting examples related to the application of VSM in manufacturing process around the world. Tyagi et al. (2015) developed practical strategies to improve product development performance achieving lean goals such as improved quality, reduced waste and shortened Product Development lead-time in a case study of gas turbine product. Oliveira et al. (2017) presented a work carried out in a company dedicated to the production of mechanical equipment, they detected several wastes and used several lean tools to eliminate waste. Singh et al. (2018) used VSM to conduct several case studies to compare improvements of Micro, Small & Medium Enterprises (MSMEs) dedicated to produce mechanical parts in India. Rohac and Januska (2015) used VSM to analyze a manufacturer of plastic products dedicated to pharmacy and health care industry, achieving important improvements impacting organization KPIs (key process indicators). Andrade et al. (2016) presented a combined use of VSM with lean tools and simulation as a complementary tool to analyze the impact of improvements, before implementing them, avoiding unnecessary costs and saving time.

2. Methodology

The projects presented in this paper were developed by three teams of Industrial Engineering students in a Mexican automotive assembly company, the students were advised by experienced engineers from the company and UANL professors for twelve weeks. The aim of each project was to identify opportunity areas in different production lines such as inventory excess, bottlenecks, time wastes, etc. using VSM tool, with the intention of improving production processes through lean tools. The VSM methodology used in these case studies is based in the work of Rother and Shook (2003). The steps are as follows:

1. Select a Product Family as the starting point. A family is a group of products that pass through similar processing steps and over common equipment through downstream processes. It is necessary to specify the selected product family, how many different finished part numbers are there in the family, how much is wanted by the customer and how often.
2. Drawing the Current State map. This is done by gathering information on the shop floor. This provides the data needed to design the Current State map (indicators such cycle time, available time, in-process inventory, etc.). Process and flow are represented by using a set of symbols or icons (Chiarini, 2012). Information is analyzed to highlight sources of waste as a preparation of Future State Drawing, which is the goal of VSM.
3. Drawing the Future State map, including calculation of takt time, identification of bottlenecks and wastes, identification of ideas for improvements, implementation of lean tools, and development of continuous flow whenever possible. (Singh and Singh, 2013).
4. Preparing implementation of work plan. This describes what is the plan to achieve the Future State map.

3. Analysis & Results

This section shows a summary of the VSM tool application and the results corresponding to each project.

3.1 Project sensor sub-assembly

<u>Product Family</u>: for this project, Sensor sub-assembly product family was selected, the information given by Production Control Section is an estimated demand 479 pieces per day. On the other hand, the supplier sends 20,000 pieces per month. Since one product require 3 pieces, the map consider a division of 20000/3 as inventory for the product family.

<u>Current State Map</u>: The process indicators for this project are four: CT (cycle time), C/O (changeover time), OEE (overall equipment effectiveness) and scrap. Additionally, raw material, finished goods, and work in process inventories were calculated. Total production lead time resulted in 19.08 days and value-added lead time resulted only as 0.0027 days, calculation of takt time is showed in current state map, giving as a result of 65.88 sec/pc as showed in Figure 1.

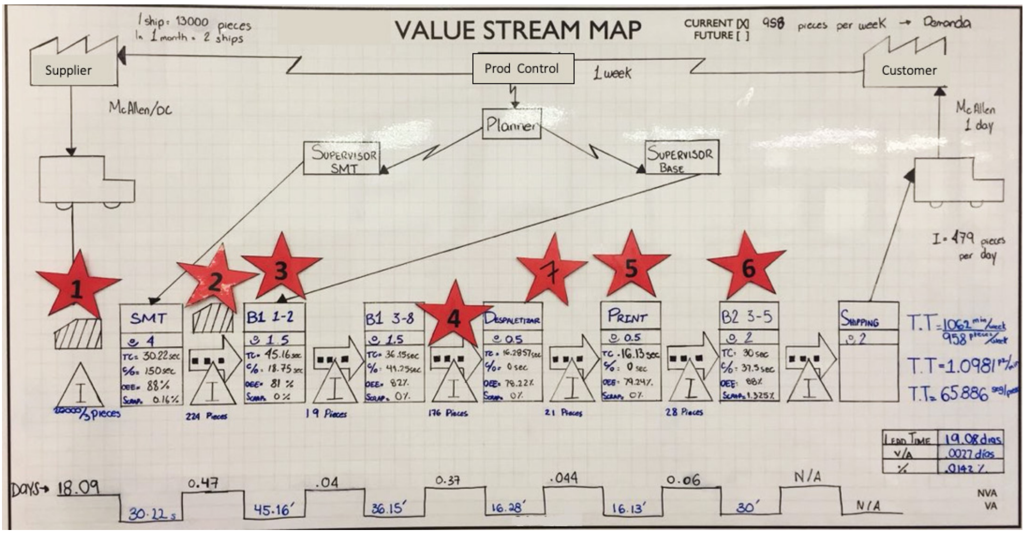

Figure 1. Current State Value Stream Map project sensor sub-assembly

Future State Map: According to the analysis of current state map the objective was to achieve a lead time of 12.07 days through 7 improvement proposed Kaizen activities: 1) Raw material safety stock reduction from 30% to 18% of average demand quantity, which was achieved after an exhaustive analysis of statistic and historical inventory data. 2) Work in process inventory reduction between SMT process and Base process, 3) reduction of 58% of curing time for epoxy resin that included experiments of surface hardness, 4) reduction of waiting time in bottleneck, one piece flow implementation and line balancing in assembly line, 5) new fixture design for printing process, 6) redesign of visual aid for product traceability, 7) redesign of fixture for functional test automation. Figure 2 shows Future State Value Stream Map.

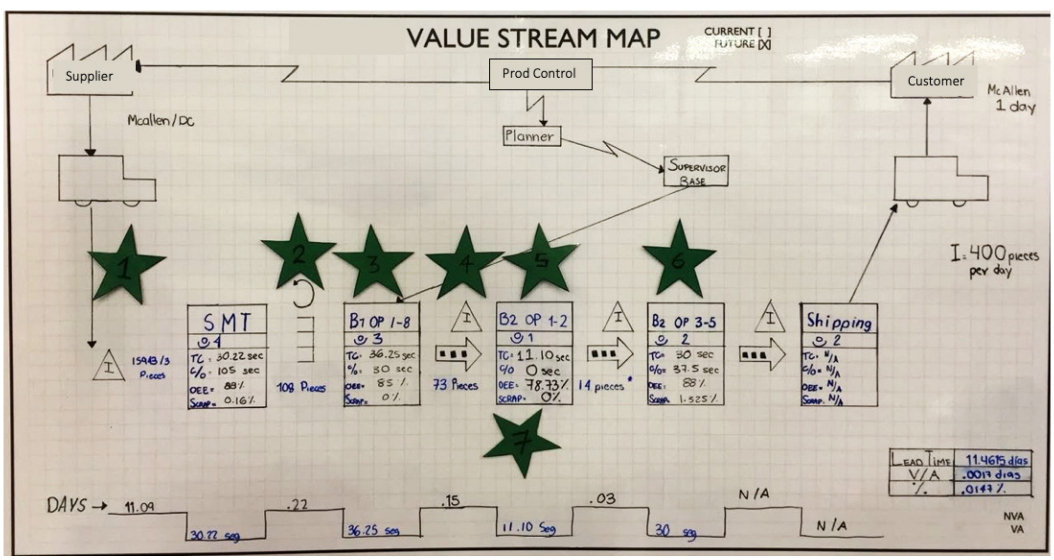

Figure 2. Future State Value Stream Map project sensor sub-assembly.

3.2 Project HVAC

Product Family: Selected product family for this project was air conditioning products for one specific customer that requires shipments to several locations in Mexico, North America and South America.

Current State Map: after collect information, opportunity areas were detected as follows: a) The OEE is 85% in the assembly area, as a world class company; the target value is 88%. b) The inventory between SMT process and Wave Solder process does not work with the principle of one-piece flow. c) The inventory between Display Assembly process and Wave Solder process is at higher levels than it should, which is 0.71 days. d) Molds changeover time of 1 hour and scrap of 1.44% in molding area. e) The way of transmitting the production plan to all areas is manually. Figure 3 shows Current State Value Stream Map.

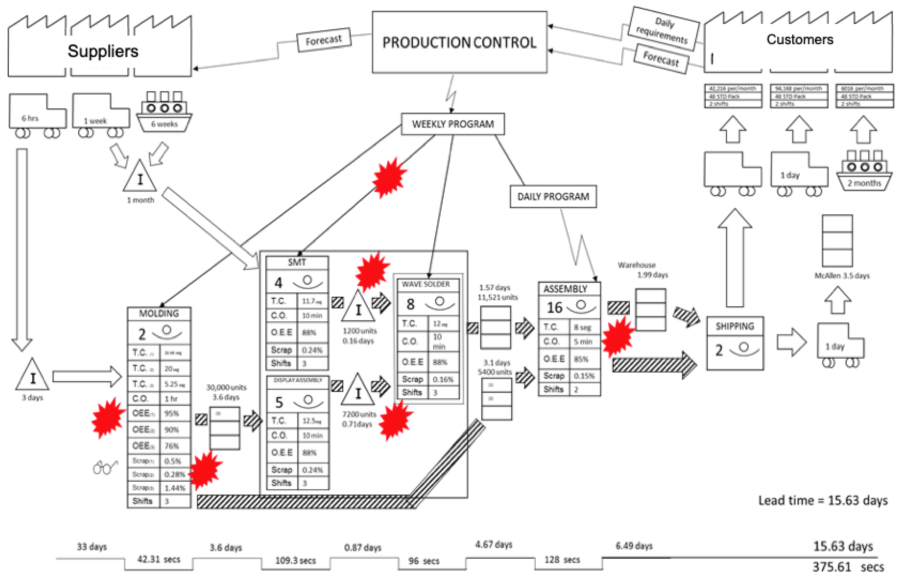

Figure 3. Current State Value Stream Map Project HVAC

Future State Map: Figure 2 shows the future VSM in which the following improvements are presented: a) Line balancing for display sub-assembly process, which implies standardizing a new process, improving assembly times and reducing the number of workstations. b) Implementation of Pull System for Visual Optical Encoder and SMT areas, design of new rack for in-process inventory, layout modification including supermarkets for PCB's, inventory adjustment according to demand and production plan, use of Andon screens to display orders sequence in SMT area. c) Reduction of changeover time through implementation of SMED tool at Molding area, including examination of internal and external elements, visual control for the hoses used for mold changes, standardization of mold designated areas and the use of a digital screen for model changes. Figure 4 shows Future State Value Stream Map.

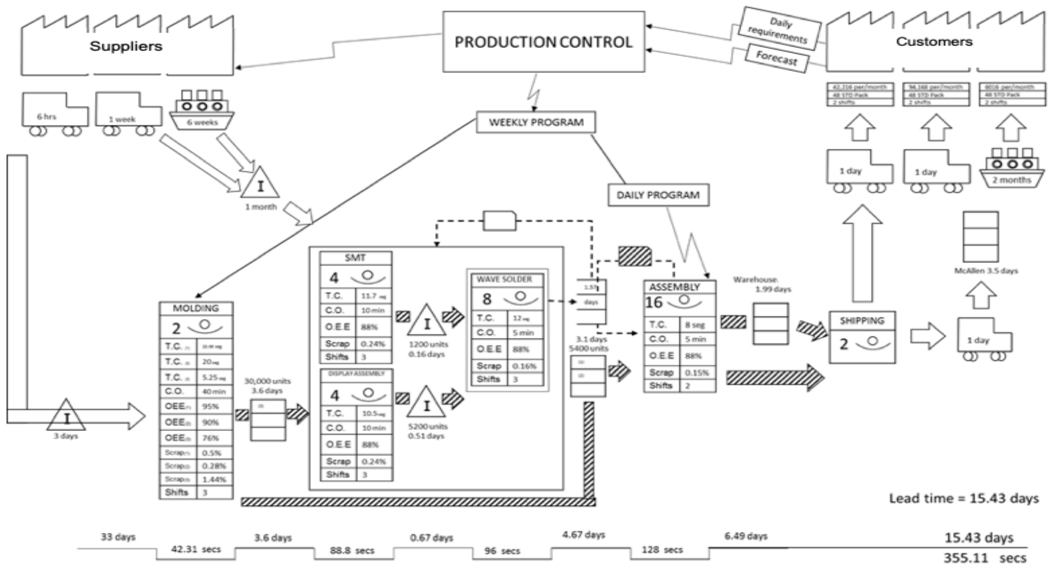

Figure 4. Future State Value Stream Map Project HVAC

3.3 Project crane control

Product Family: Crane control new product for a specific customer was selected. The product has a daily demand of five pieces. Its manufacturing is complex, as it is a completely manual assembly. Product is composed of a receiver and a transmitter, as well as a harness sub-assembly. The takt time is 96.07 minutes per piece.

Current State Map: Since only three pieces per day were produced in current situation, overtime is needed to comply with daily demand of 5 pieces required by the customer. The value stream analysis revealed the following opportunities found to increase process productivity: 1) reduction of cycle time and manual drilling process time in machining station, 2) reduction of cycle time in assembly station, 3) elimination of waiting time of 3 hours 11 minutes at cable cutting workstation and decrease of roll changeover time by 50%, 4) elimination of 12 minutes downtime caused by the search of the part numbers required to assemble the piece due to lack of drawers to place raw materials at workstation, 5) elimination of bottom assembly waiting time.

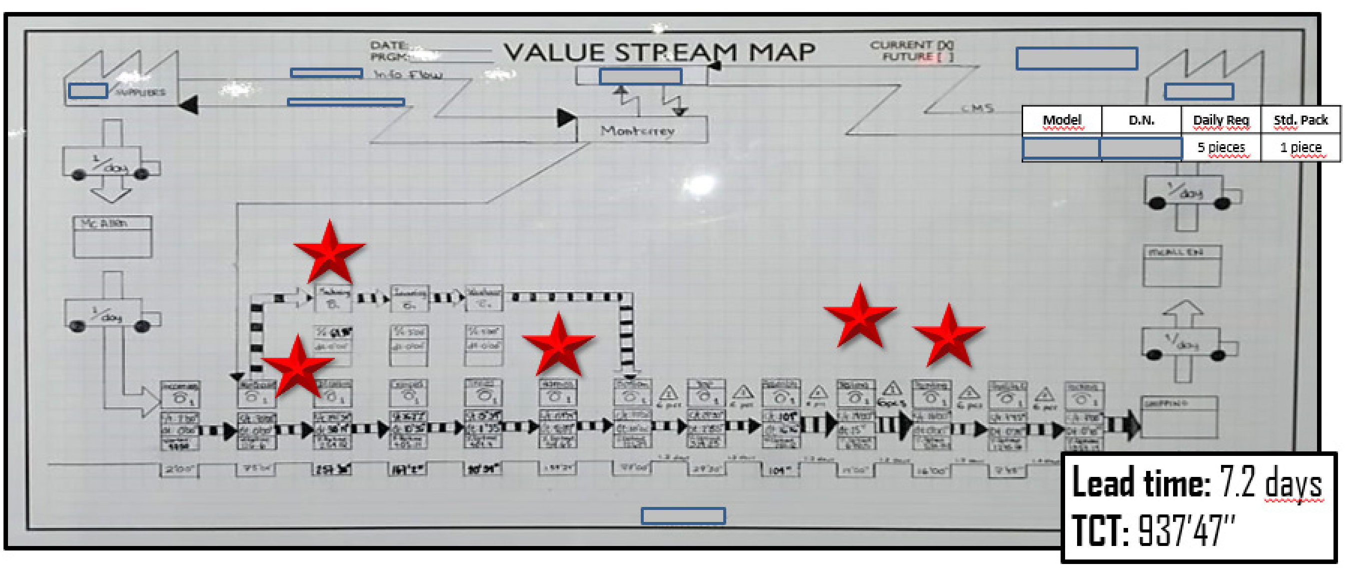

Figure 5. Current State Value Stream Map Project crane control

Future State Map: With the implementation of the Kaizen activities proposed, eight pieces can now be produced instead of five. Implemented Kaizen activities were: acquisition of a new fixture in machining area to reduce the current cycle time by 50%, also cycle time for manual drilling process was reduced by 50%. Line balancing application and Kanban system implementation in assembly area resulted in an increase of production from 5 pieces to 8 pieces per day without overtime. 5´S were applied, drawers for tools storage were installed at assembly area, also a shadow board was placed with the marked silhouette of each tool to make it easier to store and use them, in addition, cabinets with part numbers were also placed in the work tables. At the cable cutting station, the waiting time of 3 hours and 11 minutes for the crimping process was eliminated. Roll change overtime was reduced by 50%. Implementation of Kanban tool also eliminated the waiting time of 2 hours and 42 minutes (assembled, crimped, tinned and harnessed) for the harness sub assembly process. Lead time for assembly station was reduced by 50% from 7.2 days to 3.6 days, as a total result cycle time was reduced 26% in total. Figure 6 shows Future State Value Stream Map for crane control project.

4. Conclusions

The applications of Lean tools are of great importance for the improvement projects in organizations. In this work, the tools of Value Stream Map, Kanban, SMED, Line Balancing were applied, as well as other quality tools for data analysis such as Cause-Effect Diagrams, Pareto, Histograms among others, which helped to identify the main areas of opportunity, with the aim to establish improvement objectives and clearly identify processes that require changes according to the value chain. After the implementation of the action plan, significant results were obtained in each of the processes, achieving a positive impact for the benefit of the company and great learning for the students who participated in these projects.

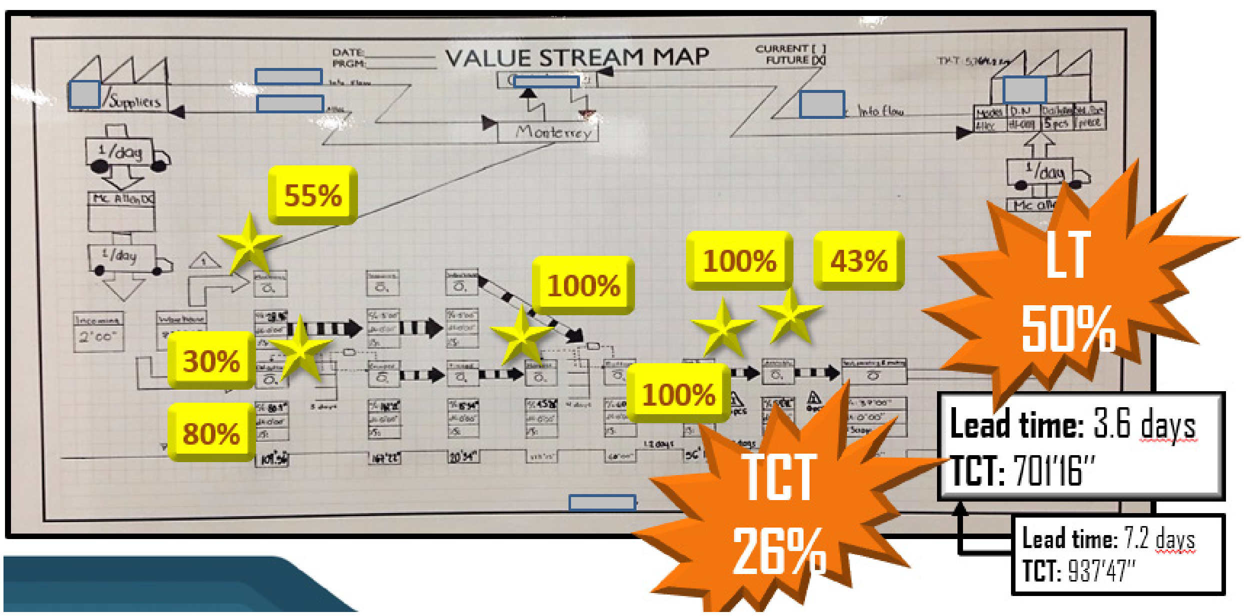

Figure 6. Future State Value Stream Map for project crane control

5. References

Abdulmalek, F. A., & 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*, *107*(1), 223-236.

Andrade, P. F., Pereira, V. G., & Del Conte, E. G. (2016). Value stream mapping and lean simulation: a case study in automotive company. *The International Journal of Advanced Manufacturing Technology*, *85*(1-4), 547-555.

Calva, R. C. C. (2011). *VSM: Mapeo del Flujo de Valor. EVSM: Extendido para Cadena de Suministro*. Rafael Carlos Cabrera Calva.

Chiarini, A. (2012). *Lean organization: from the tools of the Toyota Production System to lean office* (Vol. 3). Springer Science & Business Media.

Ohno, T. (1988). *Toyota production system: beyond large-scale production*. crc Press.

Oliveira, J., Sá, J. C., & Fernandes, A. (2017). Continuous improvement through" Lean Tools": An application in a mechanical company. *Procedia Manufacturing*, *13*, 1082-1089.

Rohac, T., & Januska, M. (2015). Value stream mapping demonstration on real case study. *Procedia Engineering*, *100*, 520-529.

Rother, M., and Shook, J. (2003). *Learning to see: value stream mapping to add value and eliminate muda*. Lean Enterprise Institute.

Shou, W., Wang, J., Wu, P., Wang, X., & Chong, H. Y. (2017). A cross-sector review on the use of value stream mapping. *International Journal of Production Research*, *55*(13), 3906-3928.

Singh, H., Bahl, A., Kumar, A., & Mann, G. S. (2018). Materials and Information Flow Analysis and Optimization of Manufacturing Processes in MSMEs by the Application of Value Stream Mapping (VSM) Technique. *Materials Today: Proceedings*, *5*(14), 28420-28426.

Singh, H., & Singh, A. (2013). Application of lean manufacturing using value stream mapping in an auto-parts manufacturing unit. *Journal of Advances in Management Research*, *10*(1), 72-84.

Tyagi, S., Choudhary, A., Cai, X., & Yang, K. (2015). Value stream mapping to reduce the lead-time of a product development process. *International Journal of Production Economics*, *160*, 202-212.

Womack, J. P., & Jones, D. T. (1997). Lean thinking—banish waste and create wealth in your corporation. *Journal of the Operational Research Society*, *48*(11), 1148-1148.