Value Stream Mapping For Headlamp Manufacturing Using Simulation Process

Tossapol Kiatcharoenpol, Puntita Sundusadee, Suthida Sareesathiensup

Abstract: Value Stream Mapping (VSM) is defined as a Lean tool that employs a work flow documenting every step in the process. Wastes, non value-added and value processes can be graphically identified by applying VSM and the users also employ the VSM as an improvement plan, implementation and tracking progress on its lean journey. However, an understanding of VSM is not easy for the outsider and shop floor employee. Therefore, the advantage of computer simulation can be used to enhance these obstacles. The clear picture of a production line and moving work flow along the layout demonstrated in a computer monitor is essential help to practitioners to gain much benefits of VSM. In this work, the VSM is applied to the headlamp production line. The current state of VSM and the improvement, a future VSM are constructed associated with applying computer simulation to process modelling of those VSMs. The Kanban, pull system and one-piece flow concepts of Lean are incorporated in the ideal VSM. It has shown that the performance of the future VSM can reduce WIP by 93% and lower lead time by 85% in the case study production line.

Index Terms: Value steam mapping, VSM, Simulation, Headlamp, Modelling

1 Introduction

Value stream mapping (VSM) is the process of visually mapping the flow of information and material as they are preparing a future state map with better methods and performance [1]. It helps to visualize the station cycle times, inventory at each stage, manpower and information flow across the supply chain. The classical version of the value stream mapping was created on the basis of the Toyota's material and information flow diagram. Firstly, this was published in the "Learning to see" in 1999 by Mike Rother & John Shook [2, 3]. This method's relevant aim is the reduction of the wastes with improvement of the logistics processes. It was applied basically on the various manufacturing fields [1,4], but recently it is also applied on the services fields [5-6]. The efficiency of the application of VSM can be increased with software support [7]. The future value stream mapping was created with use of simulation modelling. When value stream mapping is based on the simulation modelling's principle [8], so the current and the future state map are created with simulation framework. In this work, a case study in which the production flow of a headlamp is analyzed with the use of VSM. The Arena software, a computer simulation program, is also used to modelling the case production line in order to help assess wastes and process performances. The discovered problems are solved with the lean tools and suggested improvements. Then, the solutions are proposed in a future state VSM. A comparative study of process performances can be carried out using simulation models of both current and future state VSMs.

2. LITERATURE REVIEW

2.1 Value Stream Mapping (VSM)

Value stream mapping is a visual flowcharting tool used frequently in Lean manufacturing to diagram the information and material flow in a system [9]. This tool makes it possible to identify constraints, value-added time, and non-value added time—all with the intention of recognizing possible system improvements. It's often done before an improvement project to determine the current state, followed by a future-state proposal using an altered version of the map to determine the benefits of the proposed changes. There are a number of common icons used in value stream maps, but icons can also be customized to best serve a value stream map. Icons help distinguish different elements of a product line from another. For example, different arrows should be used to distinguish between product and information movement. The figure below contains commonly used icons in value stream mapping [10].

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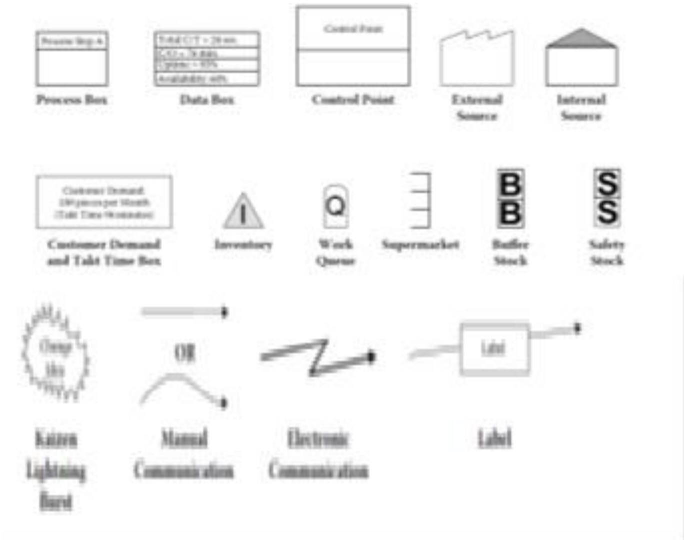

Fig. 1. *General icons of VSM*

2.2 Computer simulation of value stream mapping

Main reason to perform value stream mapping in simulation [11]:

- To Reduce the cost of data collection by reducing the number of describing processes using predefined logic blocks,
- To decease the effort by analyzing through automated modules.

With computer simulation it is possible to explore the dynamic flow effects of values which remain hidden in the static mapping of value chain on paper in a case of conventional VSM. Traditional static value flow analysis is expanded to include a critical time element of stock availability. Simulation shows the dynamic fluctuations in daily production due to batch size, setting procedure, product charges, or other faults. The main output of VSM is the image representation of the flow of values and a comprehensive view of the production of selected representative. Mapping provide a credible view of narrow production sites, the reasons for possible losses and inefficient production or storage systems.

3. MANUFACTURING PROCESS OF A HEADLAMP

A process case study conducted in this work is a headlamp production process. From the outline process chart given in in Figure 1, there are five important parts assembled to be a headlamp. The first three parts, reflector, reflector front turn and lens are fabricated in the production line, while the rest, housing and bulbs, are given by suppliers. The process starts from that plastic injection unit, the reflector, reflector front turn and lens are concurrently injected, each part is sent to keep in small in-process warehouse as Work in Process (WIP). On the next process of surface finishing, the injected plastic parts are polished, coated and finished according to their specifications. Then, all parts including housing and bulb are assembled in last station and then packed and transported to the warehouse. When customer orders are received, the headlamps are withdrawn from the finish good warehouse and shipped to customers in daily basis.

Fig. 2. *Outline flow process chart of a headlamp production*

The headlamp production line is usually working one shifts a day with 22 days a month. The average uptime for plastic injection and surface finishing machines is about 95%. In term of quality, defectives of this process are quite various among 2 to 5 per cents and the cycle times in each detail process are presented in Table 1. The takt time which is required from customer is set at about 2 minutes per piece.

Table 1.
Cycle Time of Headlamp Processes

Process	Part/process	Cycle Time (mins)
Plastic Injection	Reflector	1.13
	Reflector Front Turn	0.83
	Lens	1.17
Surface Finishing	Reflector	1.13
	Reflector Front Turn	0.5
	Lens	1.13
Assembly	Reflector, Reflector Front Turn, Lens, Bulb, and Housing	1.83
Packaging	Headlamp	0.8

2. CONSTRUCTION OF VALUE STREAM MAP AND SIMULATION MODELLING

2.1 Current state VSM and simulation model

From the headlamp manufacturing process described in the previous section, a value stream mapping can be drawn based on the data and shop floor observation, which are depicted in the Figure 3. Plastic injection, surface finishing and assembly units are three main processes of headlamp production. The first step, no.1, the production control department received the daily order form customers, then weekly forecast demand of raw material and daily production schedule are generated and distributed. Suppliers are received orders and send their material to replenish raw material stock of warehouse. This first part is focusing in information flow for the production planning control department to meet customer demand. Then in material flow, the production is run based on the daily production plan. Plastic injection unit, surface finishing and assembly units start their operation independently and keep their parts or outputs as semi-finished good or finished good in warehouses. In no.7, the shipping unit will prepare a lot of headlamp products for shipping to customer in each day. From the analysis of VSM, it approximately shows the usual work-in-process (WIP) at 1310 pieces and total production lead time at 1658.29 minutes, while the value added-time is only 4.93 minutes. The long lead time is resulting from the high WIP and high forecast production plan including safety stock to avoid shortage due to variation of actual customer demand. Although VSM is an effective tool to understand the work flow and wastes associate with the process, it is not to be easy to be apprehended by shop floor employees especially in dynamic environment when some of process parameter are changed. With capability of Simulation software, the conversion of traditional VSM paper based into computer program is really a good useful. In this way the moving object along to production work flow with quantitative display can be shown to all in user-friendly style. The simulation model by using Arena software for current VSM is illustrated in Figure 4. To verify the accuracy of simulation model, one week of five working days are simulated that provides the similar result with the actual daily production data. Moreover, the statistical data of process times, nonvalue-added, value-added, lead time, waiting time are also calculated and reported in the simulation output.

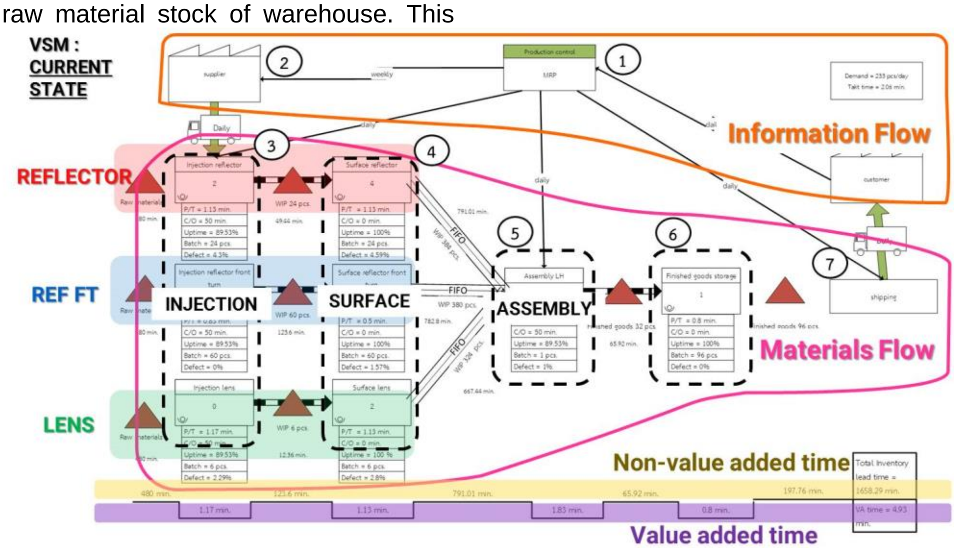

***Fig. 3**. Current state VSM for headlamp production process*

4.2 Future state VSM and simulation model

The Lean concept and tools are used in processed to design ideal flow of headlamp production resulting in minimal waste and short lead time. Such Lean tools are Pull system, Kanban system, Supermarket, FIFO and One-pieces flow. The WIP between injection, surface finishing and assembly processes are removed. The concept of daily production planning is changed from make-to-stock to make-to-order using principle of pull production system. The future VSM is shown in the Figure 5. The number of WIP in the new system is only 80 pieces and production lead time is reduced to 224.8 minutes. The computer simulation of future VSM is illustrated in Figure 6. The simulation can show the flow of material and flow of Kanban in new pull production system. The performance of current VSM and future VSM can be compared by using results of simulation models developed.

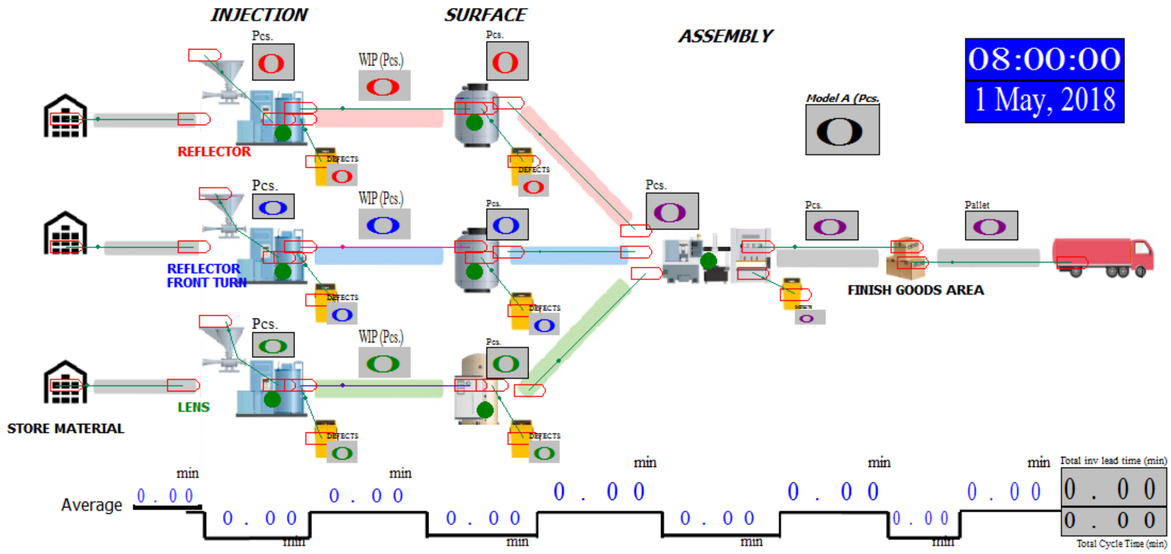

Fig. 4 Simulation modelling of current VSM for headlamp production

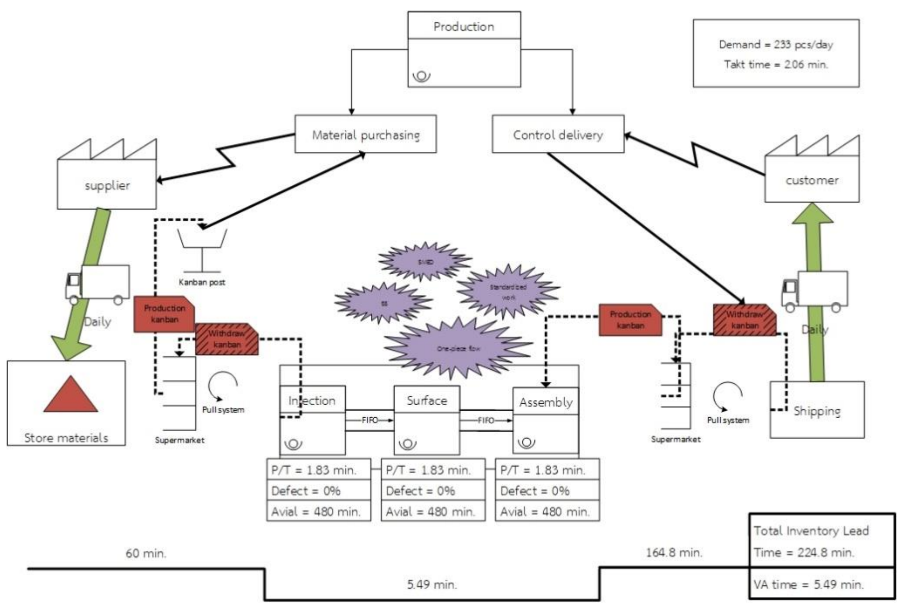

Fig. 5 Ideal state VSM for headlamp production process

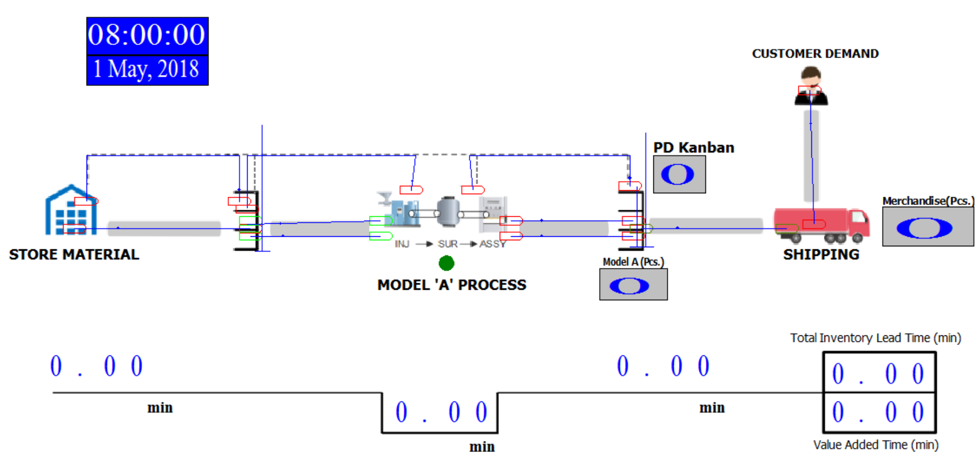

Fig. 6 Simulation modelling of ideal VSM for headlamp production

4.3 Comparison of current and future VSM results

A comparative study of performance of current state and future state is carried out by using simulation result of five working days of both states. the performances indicators of production line are presented in Table 2.

Table 2.
Comparison Results of current and future VSM

Performances	Current state VSM Simulation results	Future state VSM Simulation results
Cycle time (min.)	1.8324	1.8294
Process time (min.)	4.8704	5.4894
Lead time (min.)	1664.57	224.8
WIP/Inventory(pcs.)	1310	80

It should be noted that the future state of headlamp process are very low lead times and WIP when compared with those of current state.

5. CONCLUSION

The application of computer simulation is carried out to model VSM. The assembly process of a headlamp is a case study, which are modelling in both current and future states. The current production line is studied and VSM, a lean tool to map the process to indicate wastes to point opportunity for improvement, is applied. Then Arena software, a computer simulation program, is introduced to model the current VSM. The Image of work flow of the production can be easily demonstrated by the capability of computer software resulting in gaining understand of occurrence of wastes in the production. The batch production from separate process units and high inventory from forecast production planning are significant wastes to be removal. These all wastes are investigated to design the future state VSM including develop the computer simulation model of it. On a comparative simulation of both models, results show that new future state of VSM is highly effective than the current state VSM. After some of WIP and inventory are removed from the production line, the WIP is reduced from 1310 to 80 pieces causing very low lead time, 224.8 minutes, when comparing to present lead time at 1664.57 minutes. This enhancement of computer simulation can prove the usefulness of effectively apply to VSM to model the production line studied in more visual style to gain understand of process deficiency and easily trial various improvements to design the suitable future VSM.

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REFERENCES

[1] R. M. Belokar, V. Kumar and S. S. Kharb, "An Application of Value Stream Mapping in Automotive Industry: A Case Study", International Journal of Innovative Technology and Exploring Engineering, Vol. 1, p. 152, 2012.
[2] M. Rother and J. Shook, Learning to See: Value Stream Mapping to Add Value and Eliminate Muda (Lean Enterprise Institute), 2003.
[3] J. P. Womack and D. T. Jones, Lean thinking (Simon & Schuster Inc.), 2008.
[4] P. A. Parab and V. A. Shirodkar, "Value stream mapping: A case study of lock industry", Proc. AIP Conference, Vol 2148, 2019.
[5] S. Tyagi, A. Choudhary, X. Cai and K. Yang. "Value stream mapping to reduce the lead-time of a product development process", International Journal of Production Economics, Vol. 160 p 202-212, 2015.
[6] B. Keyte and D. A. Locher, The complete lean enterprise: Value stream mapping for administrative and office processes (CRC Press, Taylor and Francis Group), 2004.
[7] N. B. Ali, K. Petersen. and B. B. Nicolau de França, "Evaluation of simulation assisted value stream mapping for software product development: Two industrial cases", Information and Software Technology, Vol. 68, p. 45-61, 2015.
[8] D. Stadnicka and D. Antonelli, "Application of Value Stream Mapping and Possibilities of Manufacturing Processes Simulations in Automotive Industry", FME Transactions, Vol. 43, p 279-286, 2015.
[9] FlexSim Software Products Inc. Value-stream-mapping + Simulation, 2019.
[10] M. A. Nash and S. R. Poling, Mapping the total value stream: a comprehensive guide for production and transactional processes (New York: Productivity Press Taylor & Francis Group), 2008.
[11] P. Trebuna, M. Peckarcikova and M. Edl, "Digital Value Stream Mapping Using the Technomatrix Plant Simulation Software", International Journal of Simulation Model, Vol. 18, p. 19-32, 2019.