Improving productivity through value stream mapping (VSM): A case study at electrical & electronic company

A.N.M. Rose¹, N. M. Z. N. Mohamed², M. F. F. Ab Rashid³, H. M. Noor⁴, A. Mohd⁵

¹Manufacturing Focus Group, Faculty of Mechanical Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia. Tel. +60-19-9150707, Email: nasser@ump.edu.my
²Manufacturing Focus Group, Faculty of Mechanical Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia. Tel.09-4246300, Email: nikzuki@ump.edu.my
³Manufacturing Focus Group, Faculty of Mechanical Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia. Tel. +60-94246300, Email: ffaiaae@ump.edu.my
⁴Manufacturing Focus Group, Faculty of Mechanical Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia. Tel. +60-94246300, Email: hafizzuddin@yahoo.com
⁵Faculty of Manufacturing Engineering Technology, TATI University College, 24000 Kemaman Terengganu, Malaysia. Tel09-8635863, Email: alias@tatiuc.edu.my,

Abstract. This paper aims to increase productivity of a case study’s company by eliminating all possible non value added activities. The study is carried out at a speaker unit of ABC’s company, Malaysia. The current value stream map of production line was developed based on interviews, observations and other data of the company. Then, the future VSM was mapped based on the lean manufacturing principles. The current VSM was identified 12 NVA activities and the improved VSM managed to eliminate all 10 NVA activities. The elimination of NVAs was successfully achieved by applying selected lean tools and techniques. All hidden and cause of wastes were identified and eliminated. As a result the application of VSM has improved company performance by increasing the productivity by 35% and production lead time up to 400%.

1. Introduction
Poor design and ineffective manufacturing process could cause high cost implication to the company. The customer expectations are very high on product quality with minimum price. Therefore, the manufacturer has to struggle and strive for manufacturing excellence in order to survive in the market. The production team needs to come out with an ultimate solution in order to reduce consumed lead time. Lean manufacturing is defined as a systematic approach to maximize product value by minimizing waste and flowing the product through customer demand or pull system. LM also was recommended by previous researcher to all manufacturers to consider LM implementation [1, 2]. As a simple word, LM is a system that could eliminate all wastes especially on inventories and also increased the productivity [1]. Lean manufacturing is considered as the best system in 21st century. Many researches proved that LM could improve company performance by implementing comprehensive LM tools and techniques [2]. There are many tools and techniques in LM system [3].
One of the LM tools and techniques is known as Value Stream Mapping (VSM). VSM is a simple lean manufacturing tool that required a pencil and a piece of paper to illustrate overall view of the whole process flow.

The map is begins from supplier orders until the delivery to the customer including time frame. It is comprising of customer loop; production control, supplier loop, manufacturing loop, information flow and lead time data. It is a set of all activities in the production line including value added and non value added activities. The objective of VSM is to identify types of wastes and trying to eliminate them. VSM is used to illustrate the flow of a product or a group of products that use the same resources, from raw material to the end customers [4]. The most important task of VSM is to show the connection between production process and the production control including a time frame. VSM is different with other process mapping where it is only documents the basic information flow. However, VSM is mapping the whole process including the level of work in process and the movement of the materials. In this paper, the company based on electrical and electronic background was chosen as a case study company. It was established since 1999. For the sake of company secrecy, later this company will be known as Company ABC. This company manufactures speaker product including home theatre audio systems, satellite speaker, high-end audio systems, AV racks, WI-FI internet radio, WI-FI internet adaptor, outdoor speaker, bluetooth speaker, receptor radio, CD radio and car speaker Series. These products are mainly exported to Europe and USA. The company is certified of ISO9001:2015, as one of the efforts to ensure the products are always fulfil the customer specification and meets the delivery time.

In order to sustain the profit with the same price, the company has decided to reduce manufacturing cost through elimination of wastes i.e. non value added activities. Quality first is their spirit with highly requirements and stringent quality control to ensure the product is produced with the best quality. As part of continuous improvement, the company is very keen to identify and eliminate wastes. Any wastes in the production line will cause delay and low productivity. In this paper, the VSM is used to identify NVA and try to propose the possible solution for future improvement. The consideration of other lean manufacturing tools and techniques are also required such as 5S, kanban, kaizen, reduce set up time for improvement [5]. The company appreciates that if lean manufacturing implementation could reduce cycle time and increase productivity

2. Methodology

This is a case study research. There are pros and cons when compared to quantitative research. However, through single case study research, an extension of knowledge could be explored more and in depth. Case study research involves “an intensive study of a single unit for the purpose of understanding a larger class of (similar) units that observed at a single point in time or over some delimited period of time” [6]. As such, case studies provide an opportunity for the researcher to gain a deep holistic view of the research problem, and may facilitate describing, understanding and explaining a research problem or situation [7] [8].

In this paper, woofer speaker production line is chosen as a case study. It was selected because the production lead time is longer compared to other line. There are two main processes for producing woofer speaker. Process 1 has 25 sub-assemblies whereas Process 2 has 9 sub-assemblies including packaging. In order to understand the process, the walk through or Gemba has been performed for many rounds. The walk through or Gemba could see any abnormal processes such as waiting time, high work in process, part defects, unnecessary assembly process and motion. Hence, this activity could allow the team to visualize possible actions to be taken for a solution. The observation took almost a month to understand the overall process before illustrating VSM on the paper.

The investigation is started from the first process i.e. magnet assembly until delivery to the customer. In addition, the interviews also were carried out to the person in charge such as production engineer, process controller, line leader and operators. Among the questions asked were bottleneck and constraints, long queue process, most delayed process and potential for improvement. It is good to has wide range of information for data crosschecking and triangulation. An improvement team comprised of five members lead by production manager studied on each of NVA activities. All
relevant data for the current state VSM were collected. These data are cycle time, lead time, change overtime, machine uptime, number of operators, scrap rates and production size as suggested by Rother & Shook [4]. Then the production flow information is constructed on a piece of paper. The completed VSM is shown to the production engineer for verification any missing process or information

3. Results and Discussion

Total production lead time including NVA is 4.227 days whereas total value added time is 2211.4s. Figure 1 shows the current VSM. This company operates three shifts a day in 26 days per month for five identical production lines. Total demand per day is 6000 units with available working time 1300 minutes. Total workstation is 34 with 35 workers. Takt time is used to calculate the required production rate for completing a product. It is based on availability time over demand per shift. The computed takt time is 13 sec per unit. Therefore, the cycle time should be less than takt time. If longer than takt time, the production cannot fulfill the demand due to over schedule. It was discovered that the drying process took more than 13 seconds.

![Figure 1: Current Value Stream Mapping](image)

Through VSM, it was discovered 12 processes identified as NVA which consume 5284.8 s (1.468 days). Figure 2 shows the new construction of VSM after consideration some improvements. However only 10 NVA could be improved and eliminated from the production line. Two other NVAs are considered necessary and need be implemented although not required by the customer. However, these activities must be thoroughly controlled in order to reduce time or simplify the process [9]. Thoroughly studied on the VSM has provided clues for improvement. Due to limited number of allowed pages in this paper, the author will highlight the significant improvement only. As example in the process #1, the motion of refill glue is reduced from 100 minutes to 10.32 minutes. This improvement was improved through Single Minute Exchange Die (SMED) concept. Previously the worker need to refill every 2 hours compared with new procedure by once per day after change container size which could last for a day production.

After the NVA activities were eliminated, the total time is reduced from 1.468 days to 1.107 days. Total value added time is decreased to 771.4 second. Two drying processes were eliminated and contributed large reduction on total cycle time. The elimination of NVA has increased labor productivity by reducing three operators from 35 operators to 32 operators. Apart from that, the
The concept of ‘finished good supermarket’ is also introduced. The advantages of this concept are able to balance the peak demand and real cycle time. It is a part of right inventory strategy to the company. In addition other lean manufacturing tools also were implemented such as ‘kanban’ principle, pacemaker method and the new layout of U-shaped cell. Kanban is used to control flow of materials within a supply chain. This system could reduce inventory through a kanban as a visual signal for informing customer demand.

Through ‘finished good supermarket’ concept, the company could reduce total inventory by 30%. It was achieved because the supermarket signal has given a permission to the production to manufacture part when it is needed only. Previously, the storage of parts was unmanageable which cause delayed in searching. Similarly, this problem also happened in other automotive plant [10]. In addition Pacemaker is used for counter back the ‘finished good supermarket’ method where it actually simplifies the production oversight by scheduling production based on calculated takt time.

Then, Kanban system is used to control the production quantity. The principle is simply by putting a card with an inventory number that signaling the operator to produce ordered parts. By doing this, the company managed to reduce inventory by 30%. The production will only manufacture when it is needed.

The new layout of U-shaped cell arrangement has reduced the travel distance and time of the operator. The current layout is separated four stations which are, process 1 station, drying 1 station, drying 2 station and process 2 stations. The U shaped cell is supported with conveyor system which could minimized cycle time, number of operator and motion time of the operator to carry a product from one station to the next station. The operators were easily to move left and right compared to previous layout which required to walks more than 100 m per day.

Table 1 shows the comparison between current VSM and improved VSM. The improved VSM as in Figure 2 has reduced quite number of time compared to the current situation. It shows that by eliminating NVA activities i.e. travel distance, over processing and over production have influenced the improvement on production lead time, total cycle time and number of operator. As a result these improvements have improvised the productivity. The productivity of new VSM was increased by 35.4%. Previously the current VSM shows the output is 1323 units compared to new VSM with 1792
units. In addition the company also could reduce number of workers from 35 to 32 workers. This will save on emolument about RM28800 per year.

Table 1: The Comparison Before and Improved VSM

| Factor                      | Current Mapping | Future Mapping |
|-----------------------------|----------------|---------------|
| Production Lead Time (days) | 4.227          | 1.009         |
| Total Processing Time [s]   | 2211.4         | 771.4         |
| Number of Operator          | 35             | 32            |
| Output                      | 1323           | 1792          |

Production lead time also tremendously improved from 4.2265 days to 1 day, which about 400% changed. This was achieved by eliminating NVAs such as travel distance from a station to next station. Apart from that the replacement of large container for glue is also contributed to reduction of lead time. In future the company has plan to draw footsteps on the floor as to ensure the movement is within the time frame. The tremendously reduction of lead time was due elimination of 10 NVA activities that have been eliminated and two drying processes that have been replaced by installation of conveyor system. The conveyor is continuously moving according to the fixed time into oven.

All processes must follow the required time as to ensure no accumulation of work in process at a production line. Once the NVAs were eliminated successfully, number of operators also been reduced from 35 to 32 operators. This was due to some activities were eliminated and simplified such as filling glue at once per day by replacing with large container which could lasting a day consumption. In addition the conveyor system also has improved the production efficiency by automate the movement of components, which increases throughput tremendously. It also reduces the lead time, cost and operator compared to manual operations, and leads to an increase in productivity.

4. Conclusions

Value stream mapping managed to visualize the entire process of woofer speaker unit from the beginning until the end. By using VSM, the flow of information and materials are easily analysed. The application of lean tools such as kaizen, kanban and supermarket concept have assists lot of improvement in this research. As can be seen in this research, there are 10 out of 12 non-values added activities were eliminated throughout the whole process. As a result this improvement could improve the flow of manufacturing process and information. The production lead time also has improved tremendously by almost 400%. This is a great achievement to the company when the lead time could be reduced to shorter duration. In addition, the improved VSM managed to improve the productivity of woofer speaker unit production by reducing total time of non-value added activities, total time of cycle time, total time of production lead and number of operator. VSM is considered still useful tool for a manufacturing or service company to use it for waste identification and elimination. It is good if the future VSM can be simulated first before the implementation is carried out.

Acknowledgments

The authors would like to acknowledge Universiti Malaysia Pahang for supporting this research. Ref: FRGS/1/2018/TK03/UMP/03/3)-(RDU190193).

[1] Rose A.N.M., Ab Rashid, M.F.F., Nik Mohamed, N.M.Z., Ahmad, H. 2017. Similarities of lean manufacturing approaches implementation in SMEs towards the success: Case study in the automotive component industry. MATEC Web of 87.
[2] Rose, A.N.M., B.M.Deros & M.N.Ab. Rahman 2014. Critical Success Factors for Implementing Lean Manufacturing in Malaysian Automotive Industry. Journal of Applied Sciences, Engineering and Technology.

[3] Rose, A.N.M., B. Md. Deros, M.N. Ab. Rahman 2013. A study on lean manufacturing implementation in Malaysian automotive component industry. International Journal of Automotive and Mechanical Engineering vol 8 p.p.1467-1476.

[4] Rose, A.N.M., B. Md. Deros, M.N. Ab. Rahman 2013. Lean manufacturing perceptions and actual practice among Malaysian SME’s in automotive industry. International Journal of Automotive and Mechanical Engineering 7(1):820-829

[5] Rother, M. and Shook, J. 1999. Learning to See, Lean Enterprise Institute.Brookline, MA.

[6] Rohani, J.M., Zahraee, S.M. 2015. Production line analysis via value stream mapping: a lean manufacturing process of color industry Procedia Manufacturing 2 (2015) 6 – 10.

[7] Gerring, J. 2004. What Is a Case Study and What Is It Good for? The American Political Science Review Vol. 98, No. 2 (May, 2004), pp. 341-354.

[8] Baxter, P., & Jack, S. (2008). Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers . The Qualitative Report, 13(4), 544-559.

[9] Tellis, W. M. (1997). Application of a Case Study Methodology . The Qualitative Report, 3(3), 1-19.

[10] Antonelli, D., Stadnick, D. 2018. Combining factory simulation with value stream mapping: a critical discussion. Procedia CIRP 67 (2018) 30 – 35.

[11] Domingos, A.P. 2014. Implementation of lean production components supermakret in an autoparts industry – Case study. European Journal of Business and Social Sciences, vol.3, No. 9 p.p.. 191-205.