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The Implementation Lean and Green Manufacturing through Sustainable Value Stream Mapping

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Abstract. Green manufacturing is a method to minimize waste and pollution caused by manufacturing processes through the management of raw materials, energy use, production processes and health and safety issues. The implementation of Green Manufacturing can be more efficient if it is implemented simultaneously with lean manufacturing. Lean manufacturing is a principle and method that focuses on systematic identification, and elimination of non-value added activities which are involved in production and customer service. One tool that can be used for lean and green manufacturing is sustainable value strapping mapping (SVSM). SVSM covers various metrics to evaluate not only economic performance but also environmental and social sustainability. This study aims to apply the concept of lean and green manufacturing through sustainable value strapping mapping (SVSM). This study is limited to current and future SVSM. Research results show that lead time at present is 1.742.5 minutes and its energy requirement is 43,695.3 Kwh. Future state shows a 15% decrease in lead time. Improvements made are SMED on the changeover process dies.

Keywords: lean manufacturing, green manufacturing, sustainable value stream mapping.

1. Introduction

The enormous environmental awareness encourages companies to take a proactive role in designing product recycling and developing cleaner production processes and services. Thus, the green paradigm has evolved as a philosophy and operational approach to mitigate the negative ecological impact of organizational products and services and improve the efficiency of the operating environment, while achieving profitability objectives. This philosophy is widely known as green manufacturing. Green manufacturing is a method to minimize waste and pollution which is caused by manufacturing processes through the management of raw materials, energy use, production processes and health and safety issues [1][2].

The green paradigm is operationally supported by methods and tools such as environmental operations management (EOM) or known as green operation [3][4][5], green supply chain [6], eco-design [7], sustainable stream mapping [8][9], life cycle analysis [10], Multi-Criteria approach [11].

One of the tools mentioned above is Sustainable Value Stream Mapping (SVSM). SVSM is one method or tool that uses lean manufacturing approach. According to [12], Lean is a philosophy and practical ways of eliminating all waste in all production processes continuously. By applying lean principles practically can successfully improve the production process sustainably. Lean manufacturing concept is implemented based on the real condition in identifying problem and waste (non-value-added).

Lean manufacturing principles and methods focus on a systematic identification and elimination of non-value added activities involved in producing a product or providing services to customers [13]. The non-value-added activities (waste) that must be eliminated are also included in energy use and waste management of manufacturing processes. Lean Manufacturing is considered to be the most influential in manufacturing [14] as empirical evidence that enhances organizational competitiveness [15] by reducing inventory and waiting times and improving productivity and quality [16].

Sustainable value stream mapping (SVSM) is a value stream mapping that can describe the use of energy and waste generated in the manufacturing process. According to [17], value stream mapping (VSM) is a visual way that can tell the flow of material and information in the production process of a product. VSM can also be used to identify non-value added activities that occur during the production process.

Some research on lean and green manufacturing has been done. [18] Duarte et al. (2011); [19] Duarte and Machado (2015) developed a conceptual model combining lean supply chain and green into a supply chain performance measurement system. However, the theoretical model has a lack of use of the primary tool of lean manufacturing that is Value Stream Mapping (VSM). Green value stream mapping or sustainable value stream mapping is a lean and green manufacturing tool [20]. Sustainable Value Stream Mapping (Sus-VSM) is built on a traditional VSM to capture the sustainability aspect in addition to product streams, such as environmental and community aspects [21]. Lean and sustainable manufacturing are two independent theories in industrial engineering. A conceptual hybrid framework that integrates manufacturing lean with sustainable manufacturing theory, known as SdVSM mapping of sustainable value streams (SdVSM) [22]. In some production research, sustainability is often combine with Value Stream Mapping (VSM), that can blend material flows, material consumption in processes, transport energy consumption, buffers and buffers [23]. VSM is a lean tool for identifying value-added and non-value added also can check inventory level [24][25]. Energy value stream mapping can be used to achieve lean manufacturing conjunction with green manufacturing [26]. Environmental Value Stream mapping (E-VSM) can evaluate the current facility design performance and present several strategies to reduce energy consumption and production cost [27].

So far, the company has implemented Kaizen (continuous improvement) to improve its working efficiency. But the Kaizen program has not been integrated yet and has not paid attention to energy efficiency. For that, we need research for the implementation of SVSM in this company.

Based on the description of the background and the results of previous research, the focus of this research problem is how the application of green and lean manufacturing through SVSM? The purpose of this research is to apply green and lean manufacturing through SVSM.

2. Literature Review

2.1. Lean Manufacturing

According to [13], lean manufacturing, known as the Toyota Production System, was developed by Toyota Motor Company based on the principles of Henry Ford. Lean refers to principles and methods that focus on systematic identification and elimination of non-value added activities involved in producing a product or providing services to customers. Two commonly used methods in Lean are value stream mapping and Kaizen rapid process improvement events. According to [12], Lean Production is a philosophy and practical ways of eliminating all waste in all production processes continuously. By applying lean principles practically can successfully improve the production process sustainably.

Although the success of lean has been proven in the manufacturing world, there are still some challenges to be faced in the lean implementation process. [28], paid particular attention to the readiness of employees to accept lean concepts. It is challenging to ask employees to change their way of thinking to focus on the values desired by the customer and identify waste. For example, in the concept of Just in Time delivery of goods in small quantities and often, is considered to be troublesome compared with a single distribution of a significant amount. More specifically, the difficulty in identifying processes in services is that there is no physical evidence when it is compared to manufacturing. According to

[29], full management support is very influential in the successful implementation of lean. If workers feel that management is disrespectful to their efforts, there is a reluctance to continue the lean concept, which will ultimately derail the lean application [28]. Communication is an essential key to lean implementation. With the clear connection between sections, the goals and processes of implementing lean can be understood by everyone.

Engineering Lean manufacturing and lean enterprise mean that a company focuses on what the customer wants, purchased products are not defective and timely [30]. These principles can be explained as follows:

1. Customer Value, the value to be added and given, what is done is to find or capture Value desired by the customer of a product or service.
2. Value Stream, the flow of material and information. To search for non-value added activities, first must create a flow of a product or service from the beginning to acceptable by the customer. A customer does not want to pay for the activity or a production process from a manufacturer that does not value.
3. Continuous Flow, no bottlenecks, rework, just flow. How to create a stream of products or services that consist of value-added activities and replace batch and queue systems in a continuous stream
4. Pull Process - everything should be pulled from the customer. Creating a pull system mechanism by creating what customers want and when they want
5. Continuous Improvement or Perfection - strive towards it every day. This effort will be made with constant improvement.

[31] defines eight Muda (the Japanese word for waste) types: Defects or rework, Overproduction, Inventory waiting to be processed, Unneeded processing, Unnecessary movement of people, Unnecessary transport of goods, People waiting for input to work on and Design of products and services that do not satisfy customer needs.

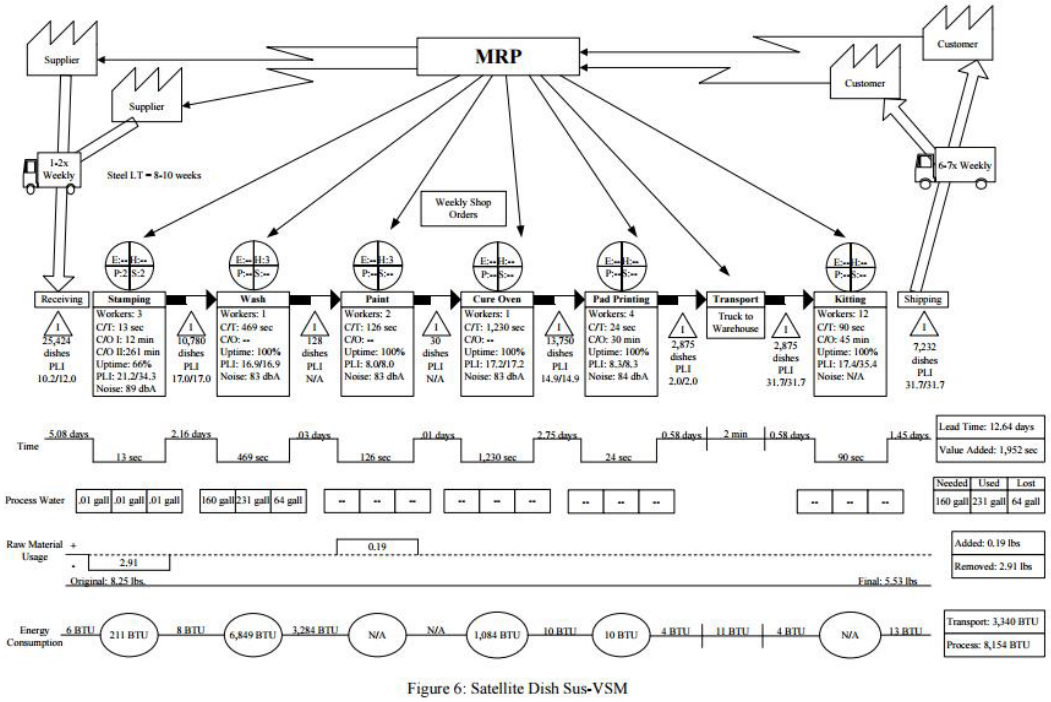

Figure 6: Satellite Dish Sus-VSM

Figure 1. Sustainable Value Stream Mapping at USA Television Satellite Factory [20]

2.2. Value Stream Mapping

According to [32], Value stream mapping is a lean management tool for analyzing and optimizing a series of events for production or service. [33] states that the flow of processes from start to finish is involved in delivering desired results, services, or value stream products valued by customers. VSM checks the flow of information and systems, as well as the flow of products or services (e.g., permits) through an agency process. VSM can improve understanding of the actual decision-making process and identify non-value added time sources of time (e.g., documents waiting to be reviewed). The VSM identifies two "current state" folders of the targeted process and the "future state" of the desired process flow folder.

Hines & Rich [15] defines the seven value stream mapping tools, that is process activity mapping, supply chain response matrix, production variety funnel, quality filter mapping, demand amplification mapping, decision point analysis, and physical structure mapping.

3. Research Method

3.1 Subjects and Research Objects

This research was conducted in electronic component industry located in Bekasi, West Java, Indonesia. The study was limited to the Department of Stamping which is one of the departments in the industry.

3.2 Research Step

Stages of this research are as follows:

1. Identification of Work Process the applicable work processes will be identified and arranged in the order of work. Based on the work process will be made current sustainable stream mapping. The new work process will be developed based on future sustainable state mapping.
2. Collection and Analysis of energy use, materials and processing time at each workstation. The energy usage data of each process will be calculated and analysed to determine the average energy usage. This average time will be placed as energy use for the process and the use of energy for transportation. In addition to energy use, also made use of materials and waste generated. Calculating the processing time to produce lead time is also done as the basis of information on value stream mapping.
3. Analysis of Sustainable Current State mapping. All job steps are collected and analysed; job steps include value added and non-value added. These steps are required for the company to complete the service from start to finish. Data is processed to make the current state mapping and fix it into an ideal future state mapping.
4. Future State mapping planning. Future mapping planning will be done after the whole picture of how the work process both from the side of the movement of the letter and time information in current state mapping obtained. In other words, future state mapping is a result of analysis of the weakness of current state mapping. Given the very detailed data about demand, inventory, schedule, cycle time. Then can see a problem that can be an opportunity to make improvements.

4. Result and Discussion

4.1. Electrical Energy Consumption

The use of energy in an electronics industry in 2016 to 2017 can be seen in Figure 2. That shows the trend of increasing energy use every month. Although there is a decrease in energy in July and August 2016 and January 2017, but in other months there was an increase.

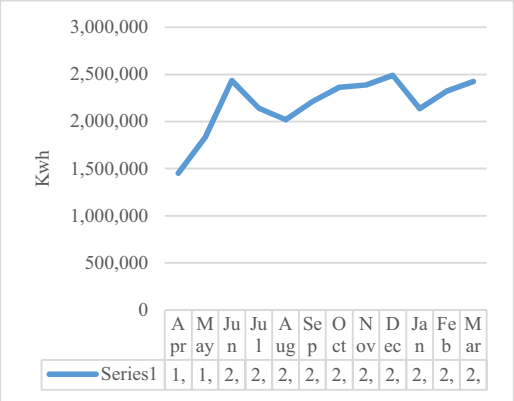

Figure 2. Energy Consumption

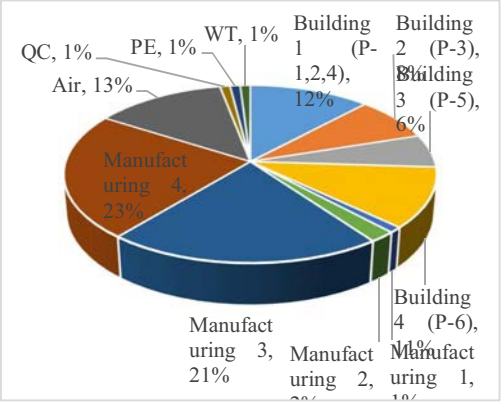

Figure 3. Distribution of electrical energy consumption

The distribution of electrical energy usage is as shown in Figure 3. The highest use of electrical energy is in manufacturing 4 / platting of 23% of total usage, then respectively from the largest to the smallest are manufacturing 3 / molding (21%), Building 1 (12%) and building 4 (11%), while others are below 10%. Some possible energy conservation possibilities to improve energy use efficiency are: 1). Energy management, 2). Manufacturing Process, 3). Utilities (compressor, pump, etc.), 4). Building (AC, lighting, fan, etc.), 5). Energy changes with some components.

4.2 Current Sustainable Value Stream Mapping

Based on the S-VSM current image it can be seen that the Lead Time stamping process is 1.742.5 minutes, which consists of NVA 1.507 minutes and VA 235.5 minutes. So it can be known that the percentage of NVA is 87%. Total electricity usage was 43,695.3 Kwh, where for a process was 17,476.9 Kwh, while other activities like transportation and material handling and machine setup was 26,218.4 Kwh. So it can be known that energy used for productive operations equals to 40% (Figure 4).

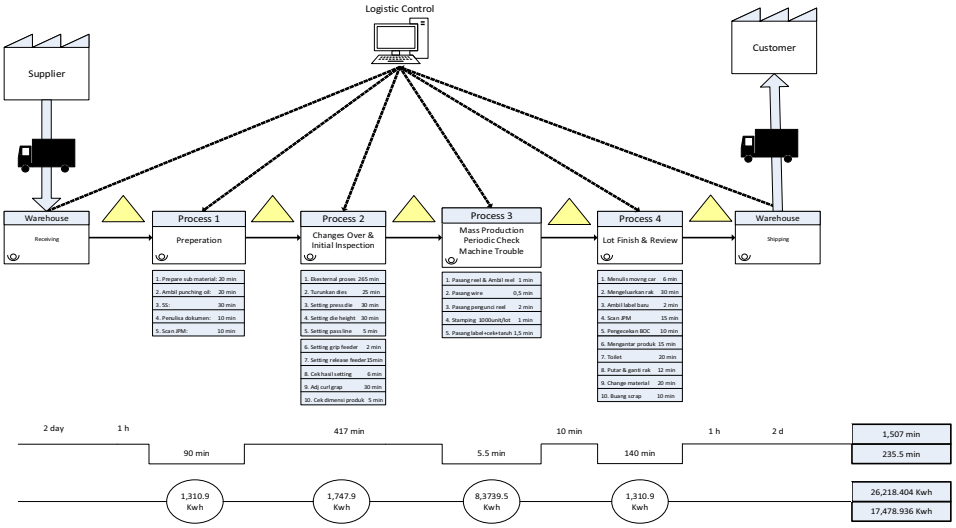

Figure 4. Current Sustainable VSM Stamping Department

4.3. Waste analysis and improvement recommendations

4.3.1. Decrease in Lead Time

Lead time was decreased by applying Single Minute Exchange of Dies (SMED) method in process two that is change over process, where the changeover process is sorted into external and internal processes. The external process can be done parallel with the running of the stamping machine, while the internal process is done after the stamping machine stops.

Table 1. External and internal process sorting in the changeover process is as follows:

1. External process	2. Internal Process
- Check the data dies 5 min	- Decrease dies 25 min
- Take & check part 15 min	- The Setting press die 30 min
- Change over part dies 240 min	- The Setting die height 30 min
- Check crane condition 5 min	- The setting line 5 min
Total external time 265 min	- Setting grip feeder 2 min
	- Set release feeder 15min
	- Check the result of setting 6 min
	- Adj curl grap 30 min
	- Check product dimensions 5 min
	Total internal time 152 min

4.3.2 Decreased energy consumption

The decrease in recommended energy consumption is as in Table 2.

Table 2. Recommendations for reducing energy consumption

No	Activities	Explanation
Lighting		
1	Replacing mercury lamps into energy saving lamps	Replacing a 400-watt mercury lamp into a 100-watt energy-saving lamp of 10 lights
2	Changing the conventional TL ballast	Replacing 15 conventional ballast units into billiard electronics
3	Replacing the TL lamp in the public area to LED light	Replace 100 lights with LED lights
Air Conditioning/ AC		
4	Changing CFC Freon on AC	Transform CFC Freon into high-quality Non CFC on 10 AC units
5	Use the timer on AC	The use of a timer on the AC will turn off the AC automatically at rest
7	Lowering pressure on water installations	Relocated the installation using a stop valve
Others Potential Saving		
8	Using airflow indoors for AC circulation	Currently using warm outdoor air, it is recommended the use of indoor air is cooler to save more on cooling.
9	Test the AC control system	Checking the AC controller, if it is not running well then replaced or bought new.
10	Uses varying compressor speeds	Add a speed controller to the compressor.
11	Control the condenser fan.	When the compressor turns off the condenser fan, make sure the evaporator is running at 100% speed.
12	Maintaining a more efficient maintenance program	

13	Optimize operating system efficiency	The operating system can control the compressor load. There is a time when 2 compressors are damaged.
20		There is always an opportunity to increase speed and decrease delays.

4.4. Future Sustainable Value Stream Mapping

Based on the analysis of waste that may be reduced, then made future S-VSM as in Figure 5. There is a NVA decrease of 265 minutes from the external process. It was equal to a decrease in lead time by 15%. The decline in lead time can be analyzed further to get better results. Based on current S-VSM it was noted that the lead time stamping process was 1742.5 minutes. Value-added activities were 235.5 minutes or 13% and activities with no added value of 1507 minutes. The energy used for the stamping department is 43,695.3 Kwh, which consists of the energy requirements for the stamping process 17,476.9 Kwh and for other activities such as transportation and material handling is 26,218.4 Kwh. Future S-VSM indicates that lead time may decrease by as much as 15% to 1.477.5 minutes. The improvement recommendation for lowering lead time is by using SMED obtained external process and internal process. The external process is done when the machine is still working. It is recommended in a decrease in energy use is by replacing the TL lamp into the LED light, AC control and air flow control for the condenser.

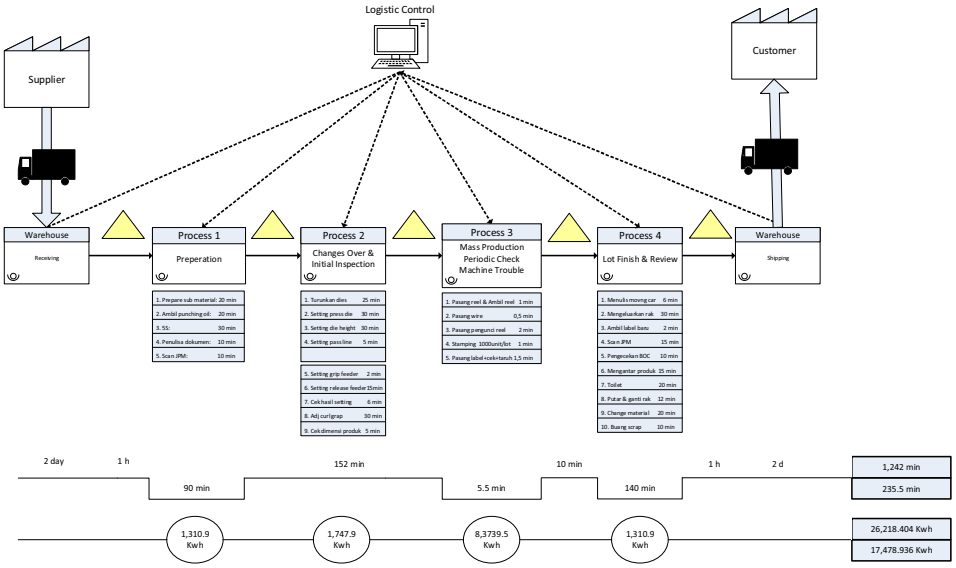

Figure 5. Future SVSM Stamping Department

5. Conclusion

Based on current SVSM, the lead time stamping process is 1742.5 minutes. Value-added activities are 235.5 minutes or 13% and activities with no added value of 1507 minutes. The energy used for the stamping department is 43,695.3 Kwh, which consist of the energy requirements for the stamping process of 17,476.9 Kwh and for other activities such as transportation and material handling is 26,218.4 Kwh. Future SVSM indicates that lead time may increase by as much as 15% to 1.477.5 minutes. The improvement recommendation for lowering lead time is by using SMED which is obtained from the external process and internal process. The external process is done when the machine is still working. The recommendation to decrease energy use is by replacing the TL lamp into a LED light, AC control and air flow control for the condenser.

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