LEAN AND GREEN VALUE STREAM MAPPING: CASE STUDY OF AN EAST JAVA FURNITURE FACTORY

Reyhan Iskandar[1] and Moses Laksono Singgih[2]

[1] Department of Industrial and Systems Engineering,
Institut Teknologi Sepuluh Nopember, Surabaya 60264, Indonesia
E-mail: reyhaniskandar@outlook.com
[2] Department of Industrial and Systems Engineering,
Institut Teknologi Sepuluh Nopember, Surabaya 60264, Indonesia
E-mail: moseslsinggih@ie.its.ac.id

Abstract. Research on lean principles in developing countries remains limited, highlighting the need for exploring alternative methods that have a positive environmental impact. One such approach is the utilization of the Value Stream Mapping (VSM) method to develop a system for waste reduction in production processes. Previous studies have overlooked the lean factor in Green VSM, making it a key aspect to be analyzed in future research. This study applies the VSM method to a furniture factory in East Java, where waste and non-value-added activities are prevalent, including bottlenecks in the lengthy paint drying process (2-3 days) and the generation of various wastes such as excessive electricity consumption, wood powder, paint residue, and wood chips. By reducing production cycle time, waste can be directly decreased. Additionally, the effectiveness of the Green Value Stream Mapping method in identifying production processes that have a significant green impact is explored. As a result, The company has the opportunity to reduce the cycle time of the production process of painting 1 by 124 seconds and painting 2 by 427 seconds, and the number of operations by 4 units

Keywords: Lean, Cycle Time, Furniture, Green, VSM

1 Introduction

Lean Manufacturing and Six Sigma are managerial applications that have been carried out in various companies, both of which are combined into Lean Six Sigma (LSS) [1]. Lean principles, although relatively old, have greatly contributed to the success of companies in developed countries such as the United States, Japan, Germany, and Italy, however, until now there has been very little research on Lean principles in developing countries [2,3] and in addition, Indonesia.

From previous research, it is proven that a green approach contributes positively to the economic, social, and environmental performance of a company [4]. One related

M. Hartono et al. (eds.), *Proceedings of the 4th International Conference on Informatics, Technology and Engineering 2023 (InCITE 2023)*, Atlantis Highlights in Engineering 21,
https://doi.org/10.2991/978-94-6463-288-0_12

system that also promotes green principles is Green Furniture. Some developing countries are starting to act to reduce the environmental impact caused by furniture companies [5]. One of them is to aggressively revolutionize green furniture manufacturing to apply sustainable development strategies to the production process. This new approach is very important for the development of modern production processes in the industrial sector [6]. Hazardous substances from furniture production, including wastewater, toxic organic chemicals, or solid waste, have raised concerns about environmental aspects [7]. There is a need for research and application to integrate alternatives that have a direct effect on the environment. According to Carvalho et al, 2017, companies that are interested in improving environmental performance will gain several benefits, such as the ability to price their products higher for consumers who care about the environment, improve the company's image, and develop new markets that make the company more competitive [8]. However, to achieve a company with good environmental performance, there are several challenges, therefore one approach that can be done is to use the Green Value Stream Mapping (Green VSM) method that focuses on zero waste, to design a system of how a company can integrate efficiency in environmental aspects in productivity.

In an earlier investigation carried out by Dimyati and Singgih [9], a comprehensive examination of the production process and its cycle time was notably absent. Additionally, the authors did not direct their attention toward the cycle duration for individual products. Through the application of value stream analysis, it becomes feasible to pinpoint the steps within the process responsible for prolonged processing and value-added durations [10]. A nation such as Indonesia possesses a significant capacity to emerge as the foremost generator of environmentally friendly products due to its abundant natural resources and a substantial quantity of small and medium-sized enterprises (SMEs) [11].

2 Research Method

The steps in this research are generally arranged in the DMAIC (Define-Measure-Analyze-Improve-Control) principle which consists of several stages, in the first stage is carried out by identifying problems, then in the second stage collecting data, after that in the third stage analyzing and evaluating the data, then in the last stage providing conclusions and suggestions for future reference.

In the course of this thesis investigation, primary information is gathered through the data collection phase. The collected information pertains to the manufacturing procedures throughout August 2022, focusing on the highest production month. Primary data is acquired through methods like direct observations, interviews, and the analysis of data directly obtained from experimental procedures. This data compilation will be conducted by:

1. Acquire information regarding the procurement of wood materials during August 2022.
2. Gather data concerning the number of manufactured items and select the specific products for examination in the research subject.

3. Construct a value stream diagram depicting the present state of the company's operations concerning the most prominent products.
4. Examine the intricacies of the product fabrication procedure more comprehensively by utilizing the operation process chart (OPC) within the existing circumstances.

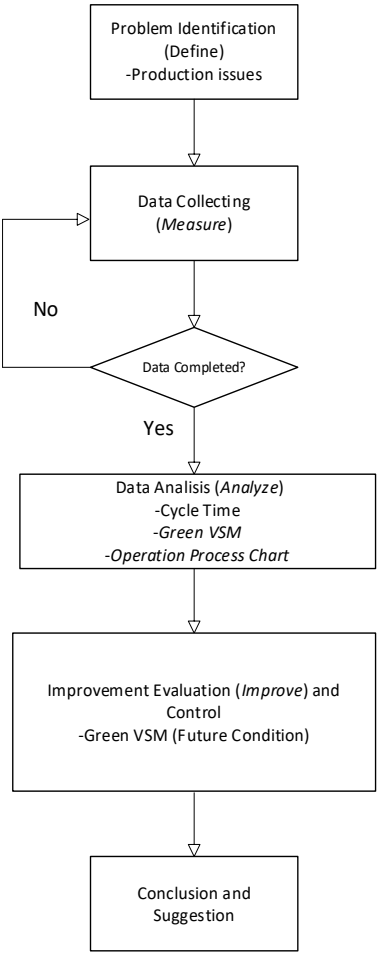

Fig. 1. Research Flow Diagram

3 Data

3.1 Company Profile

The furniture company is located in East Java that produces a variety of wooden furniture for upper-middle-class households. The company produces these products using a process in which the main raw material uses wood that has been shaped into blocks,

that consists of Medium Density Fibreboard (MDF) and mahogany solid wood. The main production activities of the company are carried out based on the procurement of stock items (Make to Stock/MTS) and partly through requests from consumers (Make to Order/MTO). So in carrying out the production process, the factory must pay attention to timeliness.

The production process at the company is still done manually, where waste and non-value-added activities are found in the production process. Waste and non-value-added activities that occur include: bottlenecks due to the paint drying process that takes too long (2-3 days), environmental conditions on the production floor are also very dusty, and the production process produces several wastes such as excess electricity consumption, wood powder residue, paint residue, and wood scraps. Through the waste in the form of remaining wood material and electricity consumption, an analysis can be made in the form of waste efficiency on the materials used during the production process.

3.2 Quantity of Furniture Production

Table 1. Furniture production during August 2022

No	Product Code	Qty
1	JOJO TV CAB	221
2	OLIVE WIDE	19
3	RS-031	18
4	CATTY TABLE	11
5	MR-018	10
6	MT MADURA	10
7	JOJO NAKAS	9
8	RS-044	8
9	MEJA BELAJAR MONACO	8
10	MT-003	7

From Table 1 it can be concluded that the product with the code "JOJO TV CAB" is the highest-produced product, which is 68% of the total production in August 2022. Thus, the data taken will use the "JOJO TV CAB" product and is expected to represent all products from the furniture factory.

Fig. 2. Product with the code of "JOJO TV CAB"

3.3 Quantity of Wood Purchased

Table 2. Order quantity of mahogany wood during August 2022

Palette	Qty	Volume (m^3)
1	314	2,15458
2	209	1,119365
3	280	1,645495
4	295	1,5533
5	201	2,6041
6	268	2,77421
TOTAL	1567	11,8511

These wood consist of a thickness from 3 to 5 centimeters with an average length and width of 13 and 180 centimeters, respectively. This wood was used to make the product coded "JOJO TV CAB".

3.4 Green VSM of Furniture Production Process (Current Condition)

Figure 3 shows the green value stream mapping of the company, several wastes occur during the production process:

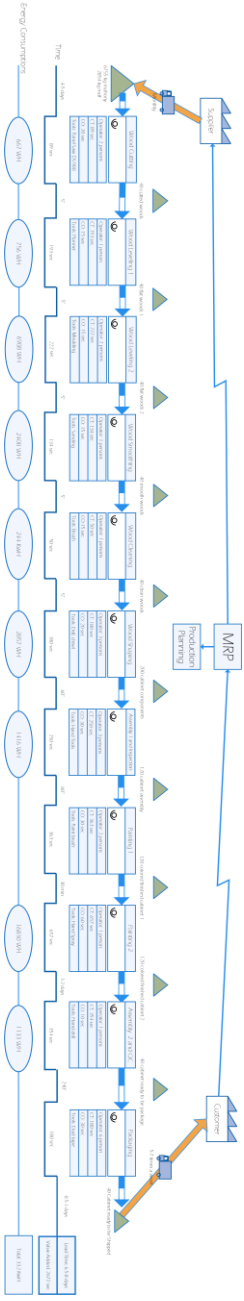

Fig. 3. Initial Green Value Stream Mapping of "JOJO TV CAB"

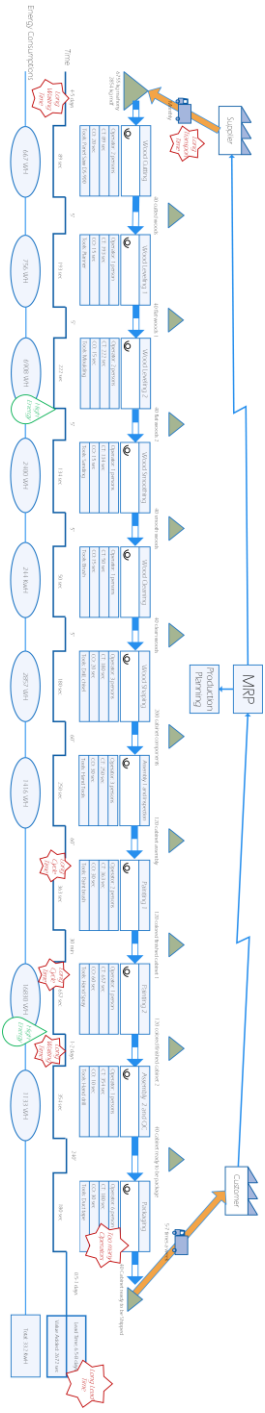

Fig. 4. Waste in Production Process of "JOJO TV CAB"

A comprehensive analysis of Fig. 4 reveals various areas in the production process where waste and inefficiencies occur. Firstly, the painting process entails a significant waste of time as the operator is left idle for two days, waiting for the paint to dry. This waiting time can be reduced through process optimization or by implementing alternative drying methods, ensuring that the operator's time is utilized effectively. Secondly, the wood shaping and leveling stages exhibit high energy consumption, indicating an opportunity for improvement. Implementing energy-efficient practices and technologies during these processes can help reduce energy usage and minimize the associated environmental impact. Thirdly, the wood cleaning process is identified as lacking value addition, as it solely involves cleaning the product without any significant improvements. Evaluating the necessity of this process and exploring alternatives to make it more valuable or efficient is crucial for waste reduction and process optimization. Furthermore, the quality control process shows inefficiencies, with defective items going unnoticed until they reach the customer. Implementing robust quality control measures and inspection protocols can help detect and address defects earlier in the production process, preventing waste and enhancing customer satisfaction. Lastly, having an excess number of operators in the packaging process indicates potential resource misallocation. Reevaluating the workforce allocation and redistributing operators to areas with higher demand, such as wood leveling and shaping, can improve overall efficiency and reduce waste.

By addressing these identified areas of waste and inefficiency, the production process can become more streamlined, cost-effective, and environmentally sustainable. Implementing strategies such as reducing waiting times, optimizing energy usage, evaluating process value-addition, enhancing quality control, and optimizing workforce allocation will contribute to a more efficient and sustainable production system

3.5 Operation Process Chart (Current Condition)

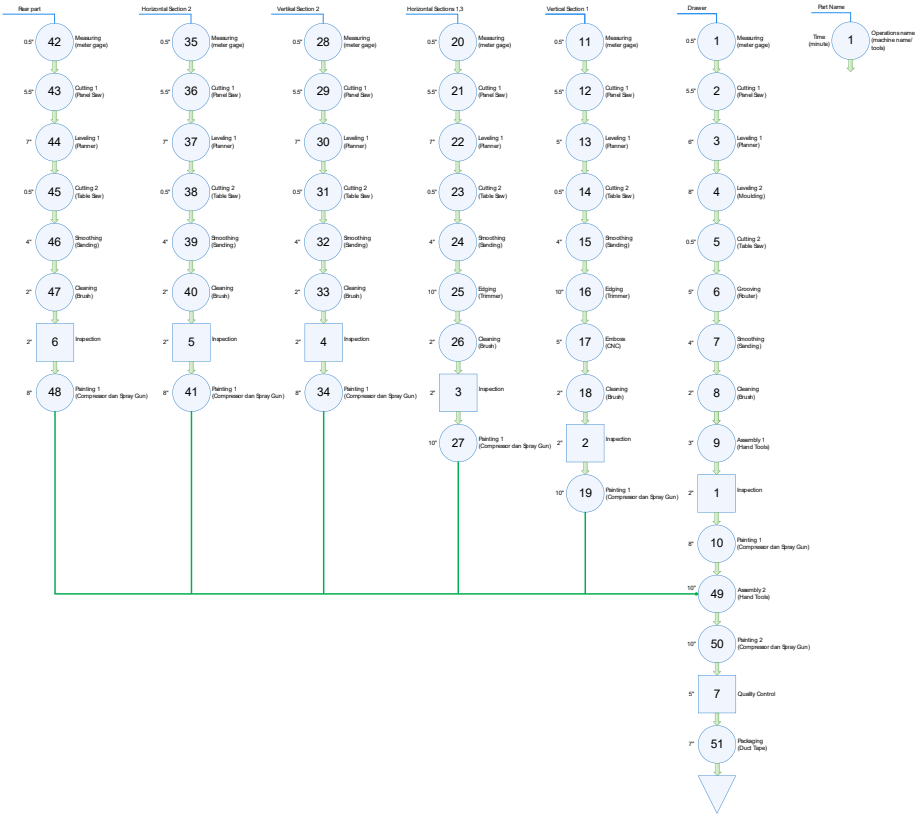

Fig. 5. Operation Process Chart of "JOJO TV CAB"

- Figure 4 is a detailed description of the "JOJO TV CAB" production process. It can be seen that the inspection activity takes a total of 17 minutes.

Table 3. Recap of Operation Process Chart

Activity	Amounts	Time (minute)
Operation	51	234
Inspection	7	11
Storage	1	-
Total	59	245

3.6 Analysis

The analysis focuses on two specific approaches:

1. Combining cleaning and smoothing processes: The suggestion to merge the machines used for cleaning and smoothing is an effective strategy for waste reduction. By combining these stages, the production process becomes more streamlined, eliminating unnecessary steps and minimizing waste generation. This consolidation optimizes machine usage and potentially improves overall efficiency. The simplicity of the cleaning machine makes it feasible to integrate it with the smoothing process seamlessly. This integration can contribute to cost savings, resource optimization, and increased productivity.
2. Transferring operators to reduce cycle time: The proposal to reallocate operators from the packaging department to the wood painting department aims to reduce cycle time in production. By having additional operators in these critical stages, the production flow can be expedited, minimizing delays and improving overall efficiency. This transfer of personnel contributes to waste reduction by reducing waiting times and bottlenecks. Additionally, the reduction in cycle time not only enhances productivity but also has the potential to detect highest electricity usage to some extent. This visualization in energy consumption aligns with sustainability goals, promoting environmental consciousness.

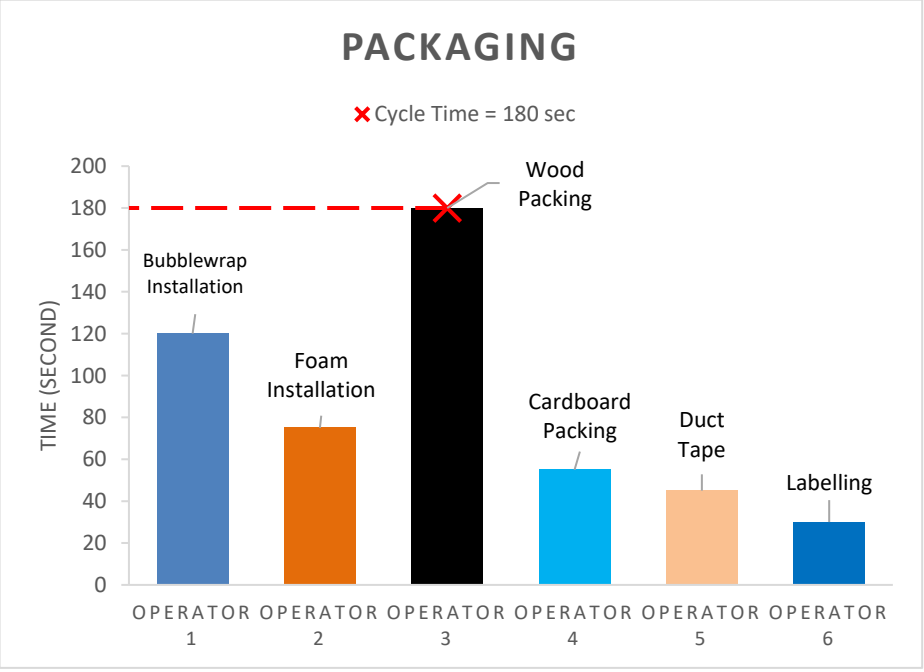

Fig. 6. Current Condition of Packaging Phase

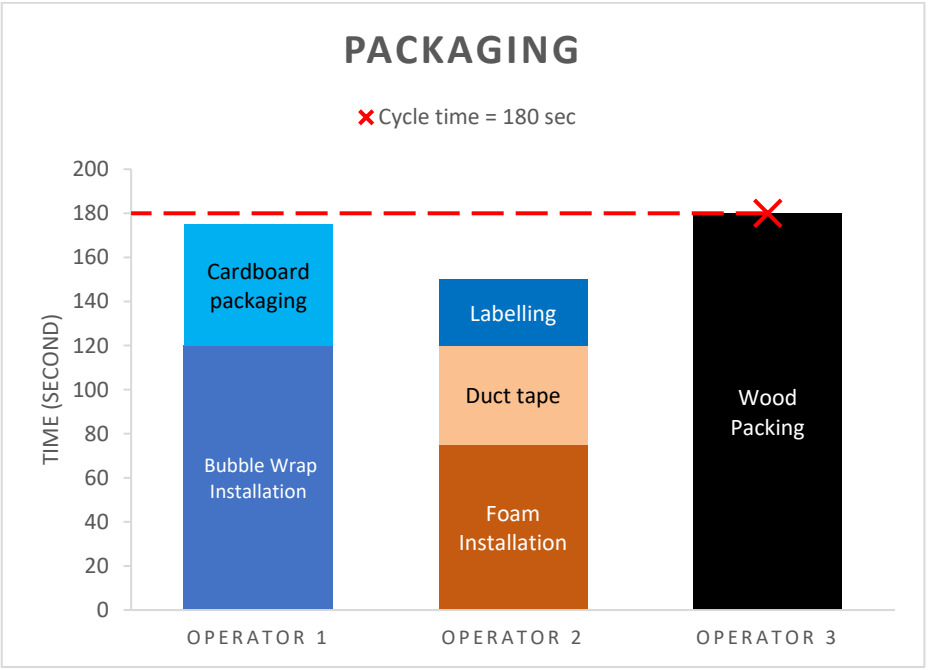

Fig. 7. Potential Improvement of Packaging Phase

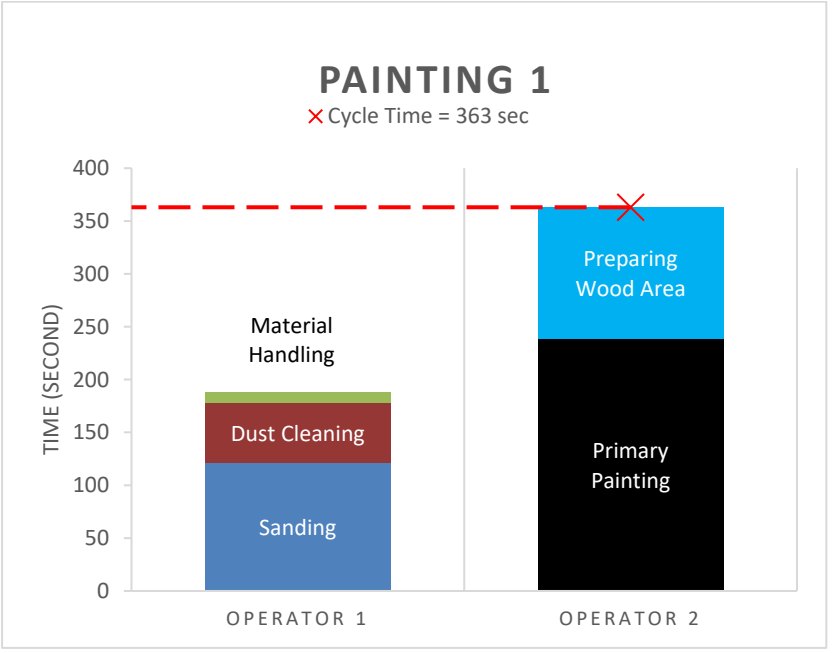

Fig. 8. Current Condition of Painting 1 Phase

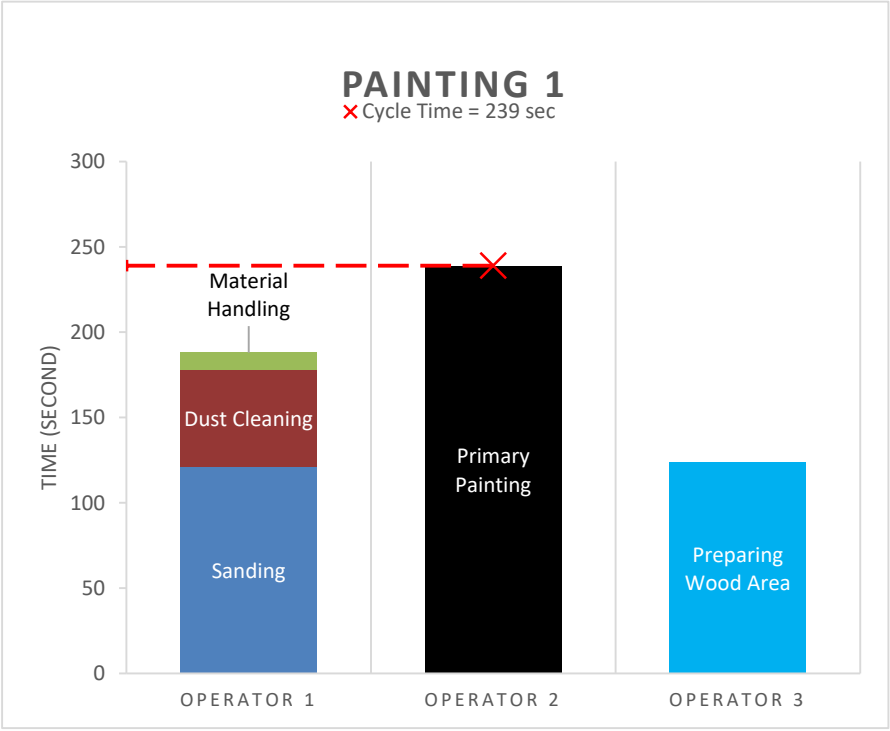

Fig. 9. Potential Improvement of Painting 1 Phase

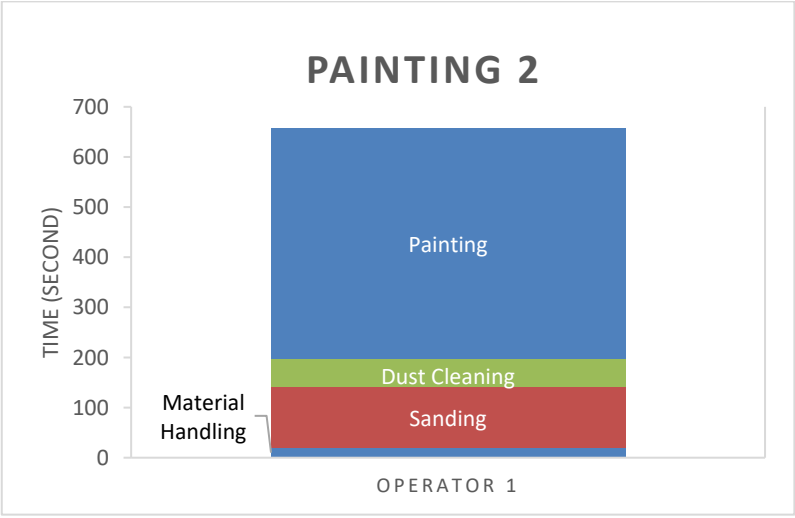

Fig. 10. Current Condition of Painting 2 Phase

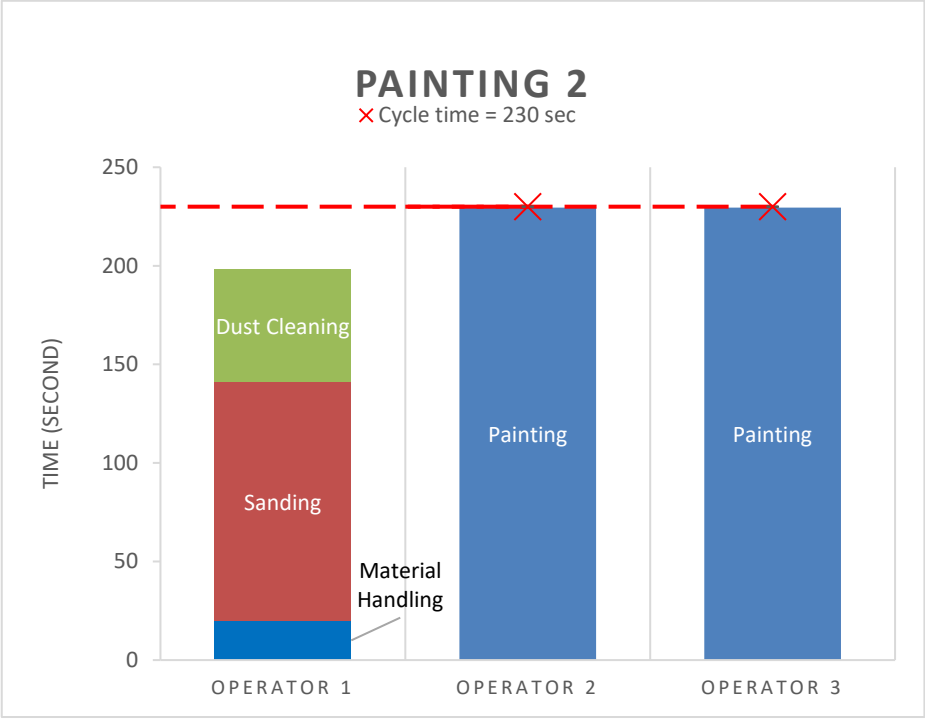

Fig. 11. Potential Improvement of Painting 2 Phase

To diminish excessive cycle time, the researcher opted for an economical approach, involving the relocation of operators from a production segment plagued by an overabundance of personnel to another process characterized by extended cycle durations. Additionally, a fusion of two processes employing basic machinery was undertaken, encompassing the following strategies:

1. Merging the smoothing and cleaning phases of production to curtail time, a consolidation that eradicates material transfer time by five minutes.
2. Transferring three operators from the packaging department to the painting 2 and painting 1 phase.

Furthermore, by constructing an eco-conscious value stream mapping diagram, the researchers pinpointed processes exhibiting the highest electricity consumption: wood leveling process 2 and painting process 2. In response, the recommendation was to provide relevant operators with training to enhance machine proficiency. This not only reduces processing time but also reduces electricity usage, ultimately aligning the company closer to the principle of zero waste.

By implementing these solutions, the production process can be optimized to minimize waste and enhance efficiency. The merging of machines and reallocating of

operators directly address specific areas that contribute to waste generation and cycle time inefficiencies. These measures have the potential to reduce costs, improve resource utilization, and promote a more sustainable production system.

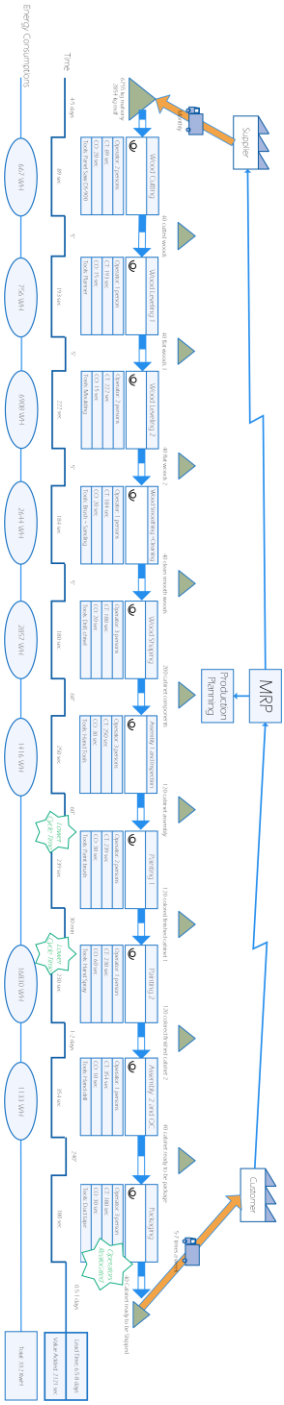

Fig. 12. Value Stream Mapping Future Conditions

4 Conclusion and Suggestions

In conclusion, the research has demonstrated the effectiveness of the Green Value Stream Mapping (VSM) method in identifying specific stages of the production process that directly impact environmental sustainability. By incorporating lean principles, this approach not only enhances productivity but also allows for the identification of environmental issues and cost reduction without compromising environmental considerations. It emphasizes the importance of integrating green practices into lean VSM to achieve economic and environmental benefits simultaneously.

Based on the analysis performed in the preceding chapter, the company possesses the potential to decrease the cycle duration for the painting process 1 by 124 seconds and for the painting process 2 by 427 seconds. Furthermore, there is a prospect to cut down the number of operations by 4 units.

For future research, it is recommended to expand the application of the Green VSM method beyond the service sector and into different manufacturing industries. This will provide valuable insights into how various sectors can leverage lean principles to achieve their environmental sustainability goals. Additionally, it is important to thoroughly investigate the transportation aspect within the value stream, as it plays a significant role in environmental impact. By analyzing transportation activities, researchers can identify opportunities for improvement and optimization to further enhance sustainability efforts.

Furthermore, future studies should explore alternative green methodologies and approaches to complement the Green VSM method. This will allow for a broader understanding of strategies to integrate environmental considerations into lean processes effectively.

By addressing these suggestions, future research endeavors will contribute to the advancement of knowledge regarding the implementation of the Green VSM method and lean principles in promoting sustainable practices across industries. Ultimately, this will aid in the development of strategies that optimize production processes while aligning with environmental goals

Engaging in research within a wood furniture manufacturing facility presents several obstacles and difficulties, which include:

1. Business Confidentiality: A wood furniture factory might possess sensitive information or procedures considered trade secrets. They could hesitate to grant complete researcher access due to concerns over potential usage by rivals.
2. Restricted Entry: Researchers could confront limitations in their ability to access specific plant zones due to privacy or security considerations.
3. Process Complexity: Crafting wood furniture involves a multifaceted procedure, comprising numerous stages and variables influencing the end outcome. Grasping these manifold factors and discerning causal relationships proves intricate.
4. Data Unavailability: Certain operational or performance data may lack comprehensive documentation or might not exist in a format suited for comprehensive analysis.

In surmounting these barriers and for the control stage, effective communication with factory authorities becomes pivotal. Gaining insight into their restrictions and challenges and devising pertinent solutions ensures the research is executed fruitfully, yielding invaluable outcomes in the future.

References

1. Megawati, E., Wicaksono, P. A., & Nurkertamanda, D. Reducing defect in furniture industry using a lean six sigma approach. In AIP Conference Proceedings (Vol. 2217, No. 1, p. 030180). AIP Publishing LLC (2020).
2. Nawanir, G., Kong Teong, L., & Norezam Othman, S. Impact of lean practices on operations performance and business performance: some evidence from Indonesian manufacturing companies. Journal of manufacturing technology management, 24(7), 1019-1050 (2013).
3. Guleria, P., Pathania, A., Sharma, S., & Sá, J. C. Lean six-sigma implementation in an automobile axle manufacturing industry: A case study. Materials Today: Proceedings, 50, 1739-1746 (2022).
4. Cherrafi, A., Elfezazi, S., Govindan, K., Garza-Reyes, J. A., Benhida, K., & Mokhlis, A. A framework for the integration of Green and Lean Six Sigma for superior sustainability performance. International Journal of Production Research, 55(15), 4481-4515 (2017).
5. Liu, F., Li, C. B., Cao, H. J., & Wang, Q. L. Green manufacturing technology connotation and system framework based on product life cycle. J. Mech. Eng, 45 (2009).
6. Pang, R., & Zhang, X. Achieving environmental sustainability in manufacture: A 28-year bibliometric cartography of green manufacturing research. Journal of cleaner production, 233, 84-99 (2019).
7. Xiong, X., Ma, Q., Wu, Z., & Zhang, M. Current situation and key manufacturing considerations of green furniture in China: A review. Journal of Cleaner Production, 267, 121957 (2020).
8. Carvalho, H., Govindan, K., Azevedo, S. G., & Cruz-Machado, V. Modelling green and lean supply chains: An eco-efficiency perspective. Resources, Conservation and Recycling, 120, 75-87 (2017).
9. Dimyati, A. F., & Singgih, M. L. Environmental Impact Evaluation Using Green Value Stream Mapping (Green-VSM) and Life Cycle Assessment (LCA). Jurnal Teknik ITS, 8(2), F157-F163. (2020).
10. Pontiana, A., & Singgih, M. L. Perbaikan Proses Produksi Jerrycan 5 Liter di PT. KEMASAN Menggunakan Pendekatan Lean Manufacturing. Jurnal Teknik ITS, 9(2), F310-F315. (2021).
11. Fernando, Y., Shaharudin, M. S., & Wahid, N. A. Eco-innovation practices: a case study of green furniture manufacturers in Indonesia. International Journal of Services and Operations Management, 23(1), 43-58. (2016).