Journal of Industrial Engineering
Scientific Journal on Research and Application of Industrial System
Volume 09 No 1 - March 2024
http://e-journal.president.ac.id/presunivojs/index.php/journalofIndustrialEngineerin
ISSN 2527-4139 (*online*) – ISSN 2503-3670 (*print*)

Application of Lean Manufacturing to Minimize Production Cycle Time in the Aluminum Furniture Division

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ABSTRACT

The production process efficiency is the company's ability to produce optimal output using available resources. When carrying out the production process of aluminium furniture, PT XYZ has a significantly long cycle time, which results in low efficiency or can be said to be experiencing wastefulness. Through the implementation of lean manufacturing using Value Stream Mapping (VSM) and Process Activity Mapping (PAM) methods, this study aims to minimize the cycle time. The production process of aluminium furniture includes (1) cutting, (2) bending, (3) assembly, (4) leveling, (5) QC, (6) Treatment, (7) powder coating, (8) weaving, (9) touch up, (10) inspect, and (11) packaging. The total cycle time for these processes is 13.431 seconds. Based on the research, it is found that there are 3 non-value-added activities, namely 2 activities in the weaving process and 1 activity in the packaging process. Elimination was carried out on 3 activities, with 2 activities in the weaving process, namely the activity of taking weaving material and tidying up weaving material, while 1 activity in the packaging process, namely the activity of taking packaging material. This resulted in a cycle time reduction of 464 seconds to 12.967 seconds.
Keywords: production efficiency, cycle time, production process, waste, lean manufacturing, value stream mapping, process activity mapping

ABSTRAK

Efisensi proses produksi merupakan kemampuan perusahaan untuk menghasilkan output yang optimal dengan menggunakan sumber daya yang tersedia. Ketika melakukan proses produksi furnitur alumunium, PT XYZ memiliki waktu siklus yang begitu besar, hal tersebut yang membuat tingkat efisiensi PT XYZ rendah atau dapat dikatakan mengalami pemborosan. Melalui penerapan lean manufaktur dengan metode Value Stream Mapping (VSM) dan Process Activity Mapping (PAM), penelitian ini berupaya untuk meminimasi waktu siklus. Proses produksi furnitur alumunium meliputi (1) cutting, (2) bending, (3) assembly, (4) leveling, (5) QC, (6) Treatment, (7) powder coating, (8) anyam, (9) touch up, (10) inspect, dan (11) packaging. Dimana dari proses tersebut total waktu siklus yang didapatkan adalah 13.431 detik. Berdasarkan penelitian yang dilakukan, diketahui bahwa terdapat 3 aktivitas yang tidak menambahkan nilai tambah (NVA) yaitu 2 aktivitas pada proses anyam dan 1 aktivitas pada proses packaging. Dilakukannya Eliminasi pada 3 aktivitas, di mana terdapat 2 aktivitas dalam proses anyaman, yaitu aktivitas mengambil bahan anyam dan merapikan bahan anyam, sementara 1 aktivitas dalam proses packaging, yaitu aktivitas mengambil bahan packaging. Hal ini menghasilkan pengurangan waktu siklus sebesar 464 detik menjadi 12.967 detik.

Kata Kunci: efisensi produksi, waktu siklus, proses produksi, pemborosan, lean manufaktur, value stream mapping, process activity mapping

1. Introduction

The industrial world is developing very rapidly, accompanied by intense competition, including the furniture industry. The furniture industry is one of the fields with intense competition due to the large number of businesses competing directly at both local and international levels (Afif & Purwaningsih, 2018). Currently, furniture has become one of the economic sectors experiencing significant growth in Indonesia. This industry has the ability to provide interior designs and artistic value that can enhance comfort and encourage activities. The aluminium furniture industry plays a strategic role in meeting consumer needs for furniture products made of aluminium material (Zamroni & Mundadi, 2017).

From the raw materials perspective, Indonesian furniture has the highest export value. In 2021, wooden furniture products contributed 69% to the total export value, while rattan and bamboo materials contributed 7%, metal 6%, plastic 3%, and other raw materials each contributed 3%. However, in terms of the percentage increase in total export value, furniture made of metal raw materials saw the highest surge in 2021, reaching

 DOI: https://doi.org/10.33021/jie.v9i1.4848

59.03%. The next highest increase was in the export of rattan/bamboo furniture, which strengthened by 43.41%, followed by wooden furniture, which increased by 32.54% (Pusdatin Kemenperin, 2022).

This concept strives to make products in a sustainable manner while retaining global competitiveness and tackling the most recent difficulties and problems. It is a manufacturing system method that considers economic, environmental, and social factors (J. K. Y. Lee et al., 2021). Procurement management is going to be essential to the entire value stream process in order to continuously improve quality, quickly fulfill client requirements, and increase competitiveness. Finding a study that looks at how to enhance procurement management processes from a value flow perspective is unusual, though (Batwara et al., 2023).

Manufacturing companies engage in non-value added activities, which lead to suboptimal resource utilization and waste production (Ristyowati et al., 2017). Depending on the scale and intricacy of the enterprise, the production line for furniture fabricated from metal raw materials may confront a variety of obstacles. An ongoing challenge encountered by PT XYZ pertains to the production efficacy of metal furniture. The production process of PT XYZ is characterized by an exceptionally lengthy cycle time, resulting in diminished efficiency. It is critical to minimize the cycle time of the products in order to maximize output and decrease production expenses. In addition, by decreasing the duration of the production cycle, unnecessary human or machine resource deficiencies, as well as oversights in supply chain management, can be prevented. Manufacturing companies engage in non-value added activities, which lead to suboptimal resource utilization and waste production (Ristyowati et al., 2017).

The significance and implementation of the waste elimination concept across diverse industries are influenced by a multitude of approaches (Turseno et al., 2018). The concept of lean manufacturing, which aims to accomplish ongoing improvement by identifying and eliminating waste in the production process and optimizing value for the customer, can be utilized to reduce the production cycle time of metal furniture (Satao et al., 2012). It is anticipated that by implementing the lean manufacturing methodology for waste identification and elimination, the organization will conserve resources and, naturally, increase output. In order to achieve the quality, cost, and delivery objectives of the organization, the lean manufacturing system was selected (Kundgol et al., 2019). PT XYZ is an organization that operates within the metal furniture sector. A low level of production efficiency at PT XYZ is the current issue; this is attributable to non-value-added activities. It is critical to minimize product cycle time in order to maximize output and decrease production expenses.

Lean manufacturing theory is applicable in two distinct manners. The initial objective is to identify and eradicate production-affecting waste. The second approach places emphasis on balanced and efficient manufacturing procedures (Deshkar et al., 2018). Also essential for the implementation of lean manufacturing are Process Activity Mapping (PAM) and Value Stream Mapping (VSM). Visual Supply Chain Management (VSM) is a visual mapping methodology employed to assess and depict the information and material flow throughout the entire production cycle (Satao et al., 2012). Organizations can utilize VSM to detect waste and implement suitable measures to enhance the overall flow of production. Subsequently, PAM is a conventional approach that documents every activity by classifying them according to their type, time of occurrence, activity proportion, and the factors deemed to have an influence on the process (Ristyowati et al., 2017). The implementation of enhancements through the identification and elimination of waste is anticipated to yield resource savings for the organization.

Lean manufacturing's primary objective is to optimize space, minimize costs and waste, and decrease time in order to increase value in an effective and efficient manner (Muhammady, Z., 2020). Lean production is predicated on the capacity to operate in concert to establish a system that ensures the delivery of superior products that satisfy the needs and desires of consumers (Hardianza, 2016). Information, materials, procedures, and other components are all denoted by standard symbols in VSM (Q. Lee & Snyder, 2007).

Small business management can leverage the VSM method to mitigate fluctuations and irregular production patterns, enhance their production system and flexibility, thereby bolstering their competitiveness and resilience against abrupt external threats (Susilawati et al., 2021). The value stream is modeled by retracing one's steps through the process, documenting all operational process steps, pertinent information to depict the process steps' performance, and the implemented control methods. This is achieved through the use of the traditional symbols of the VSM (Busert & Fay, 2019). The percentage of the most substantial or preponderant waste can be ascertained through an observation process utilizing the Process Activity Mapping (PAM) method (Kasanah & Suryadhini, 2021).

In addition to Ohno's seven wastes, the selection of wastes is influenced by the significance of understanding the supply chain's overall architecture (Hines et al., 1998). There are two distinct types of waste: type one waste, which is recurring and does not contribute value, and type two waste, which does not add value. Non-value-adding refuse (type 2) may be removed from the operating system, as it poses a threat to the operation

of the company. It is imperative to promptly identify and dispose of this refuse (Gaspersz & Fontana, 2007). Businesses can identify waste and implement the necessary measures to enhance the overall flow of production using VSM. PAM is a conventional approach that maps the entire process by gathering all activities in accordance with their type, time presentation, activity proportions, and the elements that are ascribed to each process and are deemed to influence it. The implementation of VSM and PAM can yield enhancements by means of waste identification and elimination, which in turn reduces the amount of cycle time required.

2. Methods

The aim of this research is to eliminate waste at PT XYZ. The process begins with on-site observation of the company and conducting interviews with the working operators. Subsequently, waste is identified based on the 7 types of waste according to "The Toyota Way" (Liker, 2014), namely Defect, Overproduction, Inventory, Overprocessing, Transportation, Waiting, and Motion.

Gasperz & Fontana (2011) explain that there are five basic principles in the journey of lean manufacturing:
a. Identify based on the consumer's perspective on the desired product quality.
b. Identify value stream mapping in each process area.
c. Eliminate non-value-adding activities throughout the production process.
d. Organize the flow of information and materials to be smoother and more efficient with a pull system.
e. Achieve continuous improvement and maximum performance by constantly seeking improvement tools and techniques.

Using Value Stream Mapping (VSM) and Process Activity Mapping (PAM), process categories are categorized as follows: Value Added (VA), Necessary Non-Value Added (NNVA), and Non-Value Added (NVA). Non-value-added activities are eliminated, and a representation is generated in accordance with the recommendations put forth by Value Stream Mapping (VSM) and Process Activity Mapping (PAM) after the work process has been classified into three categories (Q. Liu and H. Yang, 2020). Current-state VSM provides a graphical representation of the manufacturing system's procedures. Cycle time, transition time, work-in-process (WIP) levels, and other pertinent information are included (Q. Liu and H. Yang, 2020). In conclusion, conclusions are drawn from the conducted analysis.

3. Result and Discussion

During the production process, the Porto Dining Chair consists of 9 parts starting from the back legs, front legs, support for curved backrest A, support for upright backrest B, support for lower curve A, support for lower curve B, support for front lower A, support for front lower B, and support for lower C. This production process is depicted in the operation process chart, with a total time of 12.884 seconds, a total of 38 process operations, 4 repetitions, and 6 inspections. For a clearer understanding, please refer to Table 1.

Table 1. Summary of OPC Porto Dining Chair

Conclusion		
Activities	Quantity	Time (S)
Operation	38	11536
Repeat	4	198
Inspect	6	1150
Total	44	12884

Table 2 is the cycle time data of the production process at PT XYZ, which has previously undergone a data adequacy test with sufficient results and a data uniformity test with consistent results.

Table 2. Cycle Time Process Production

Production Process	Activities	Code	Time (S)	Total
Cutting	Inserting Material into the Cutting Machine	1 A	36	128
	Cutting Process	1 B	72	
	Moving Cutting Results	1 C	20	
Bending	Installing the Cutting Material into the Bending Machine	2 A	7	588
	Bending Process	2 B	186	
	Bending Inspection	2 C	375	
	Transferring Bending Results	2 D	20	
Assembly	Taking Bending and Cutting Results	3 A	10	5290

Production Process	Activities	Code	Time (S)	Total
	Welding Process	3 B	2713	
	Transferring Welding Results	3 C	15	
	Taking Welding Results	3 D	15	
	Full Welding Process	3 E	2532	
	Transferring Full Welding Results	3 F	15	
Leveling	Taking Full Welding Results	4 A	20	519
	Grinding Process	4 B	245	
	Sanding Process	4 C	244	
	Transferring Leveling Results	4 D	10	
QC	Retrieving Leveling Results	5 A	10	655
	QC process	5 B	630	
	Transferring QC Results	5 C	15	
Treatment	Taking QC Results	6 A	15	116
	Treatment Process	6 B	96	
	Transferring Treatment Results	6 C	5	
Powder Coating	Taking Treatment Results	7 A	5	315
	Powder Coating Process	7 B	300	
	Transferring Powder Coating Results	7 C	10	
Woven	Taking Powder Coating Results	8 A	20	4316
	Taking Woven Material	8 B	188	
	Tidying Woven Material	8 C	156	
	Weaving Process	8 D	3934	
	Moving Woven Products	8 E	10	
Touch Up	Taking Woven Products	9 A	8	164
	Touch Up Process	9 B	146	
	Moving Touch Up Results	9 C	10	
Inspect	Retrieving Touch Up Results	10 A	7	165
	Inspection Process	10 B	145	
	Transfer Inspect Results	10 C	13	
Packaging	Taking Inspection Results	11 A	10	1175
	Taking Packaging Materials	11 B	120	
	Packaging Process	11 C	1032	
	Transferring Packaging Results	11 D	13	
Total				13431

3.1 Value Stream Mapping

Value Stream Mapping (VSM) is a mapping concept that includes a detailed breakdown of the flow of information and the flow of goods, starting from raw materials through the production process until the product exits as a finished item ready to be delivered to consumers. Figure 1 is the Current State Value Stream Mapping (CVSM), which represents the condition of the process flow map for PT XYZ's finishing process during the observation.

3.2 Process Activity Mapping

By using Process Activity Mapping, the entire production process can be seen in more detail. Each process step is broken down into a series of specific activities that will be assessed to determine whether they add value to the company (value-added), whether they are necessary for the company to achieve a product (necessary but non-value-added), or whether they do not add value at all (non-value-added). Through the creation of Process Activity Mapping, activities that lead to waste can be identified more clearly and in greater detail. The mapping roach in the process activity map also has greater depth compared to the value stream mapping described in Figure 1.

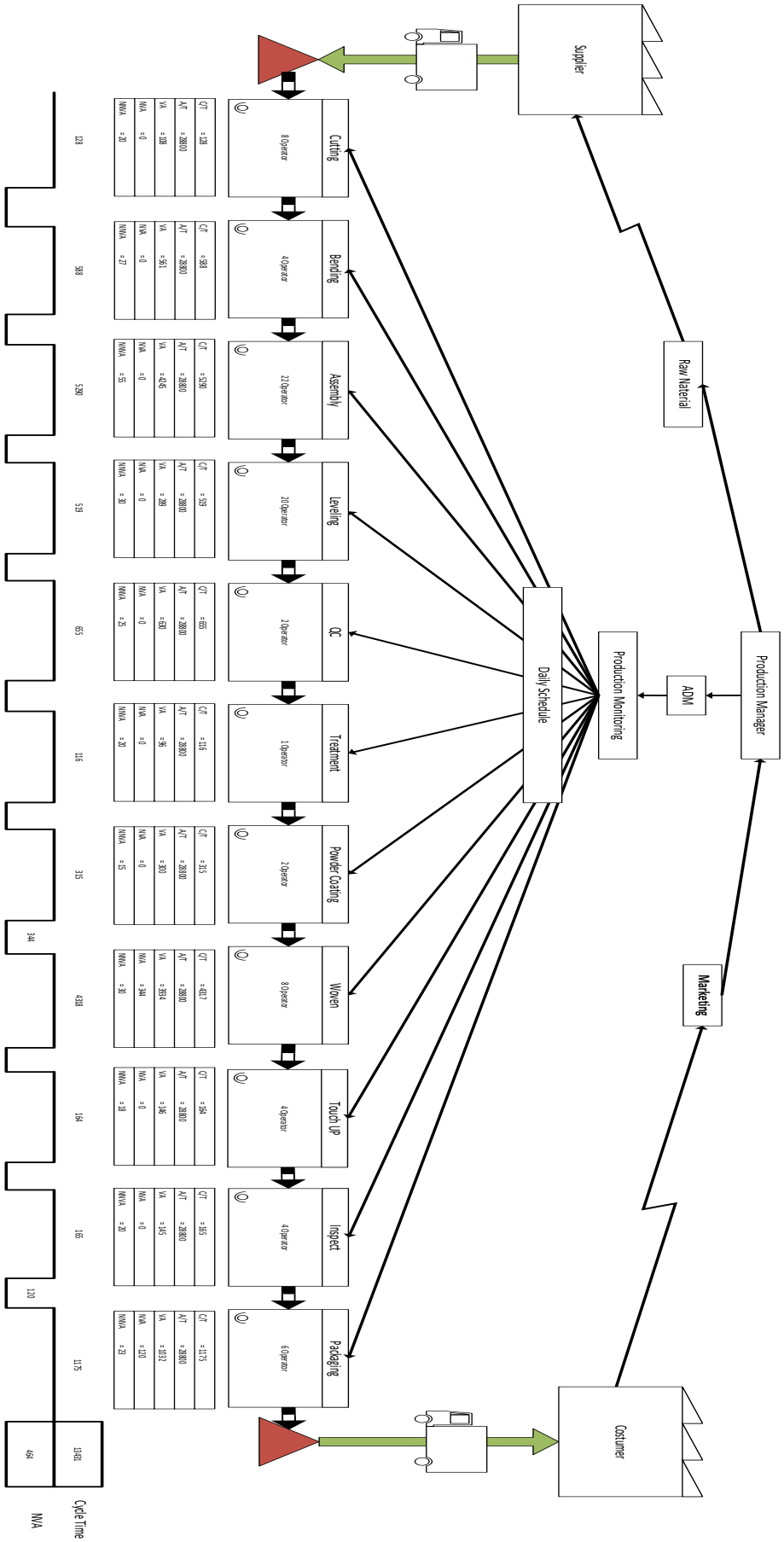

Figure 1. Current State Value Stream Mapping

Table 3 presents the process activity map of the production stages in the aluminium division of PT XYZ.

Table 3. Process Activity Mapping

Production Process	Activities	Machine	Distance (m)	Time (S)	Type of Activity					VA/NVA /NNVA
					O	T	I	S	D	
Woven	Taking Powder Coating Results	Manual	12	20		T				NNVA
	Taking Woven Material	Manual	6	188		T				NVA
	Tidying Up Woven Material	Manual	0	156					D	NVA
	Weaving Process	Manual	0	3934	O					VA
	Moving Woven Products	Manual	12	10				S		NNVA
Packaging	Taking Inspection Results	Manual	2	10		T				NNVA
	Taking Packaging Materials	Manual	8	120		T				NVA
	Packaging Process	Manual	0	1032	O					VA
	Transferring Packaging Results	Manual	8	13				S		NNVA
	Total		130	13431	14	12	2	12	1	

Explanation:
O = Operation
T = Transportation
I = Inspection
S = Storage
D = Delay
VA = Value Added
NVA = Non-Value Added
NNVA = Necessary but Non-Value Added

Based on the process activity mapping table, three activities that are part of Non-Value Added (NVA) or no value addition were identified in the weaving process. These activities include gathering weaving materials and tidying up weaving materials in the weaving process, as well as gathering packaging materials in the packaging process. The total time spent on these three activities without adding value is 464 seconds or 7 minutes and 44 seconds. After determining the time without value addition, it is necessary to eliminate these activities from the process.

3.3 Discussion

From the current state value stream mapping depicted in Figure 1, two processes indicate wastefulness. Waste is observed in the weaving process and the packaging process. This is further explained in Table 3 on activity mapping where in the weaving process, there are 2 Non-Value Added (NVA) activities which are the movements of taking weaving materials for 188 seconds and tidying up weaving materials for 156 seconds. In the packaging process, there is waste in the activity of taking packaging materials for 120 seconds. A more detailed analysis will be discussed in the activity process mapping analysis.

After eliminating the weaving material retrieval activity (8B), tidying up the weaving material (8C), and taking packaging materials (11B), the future state value stream mapping is depicted in Figure 2. The cycle time has been reduced by 464 seconds. Based on the current value stream mapping in Figure 1 and the process activity mapping in Table 3, the total cycle time has decreased from 13.431 seconds to 12.967 seconds.

For the Process Activity Mapping, two types of Non-Value Added (NVA) activities were identified, namely Transportation (T) and Delay (D). To eliminate these three activities, the production layout was modified to avoid repeating them. As a result, the total time was reduced by 464 seconds, from 13,431 seconds to 12,967 seconds, and the total distance was reduced from 130 meters to 116 meters. Moreover, the number of activities was also reduced, with transportation activities decreasing from 2 to 1, and delays decreasing from 1 to 0.

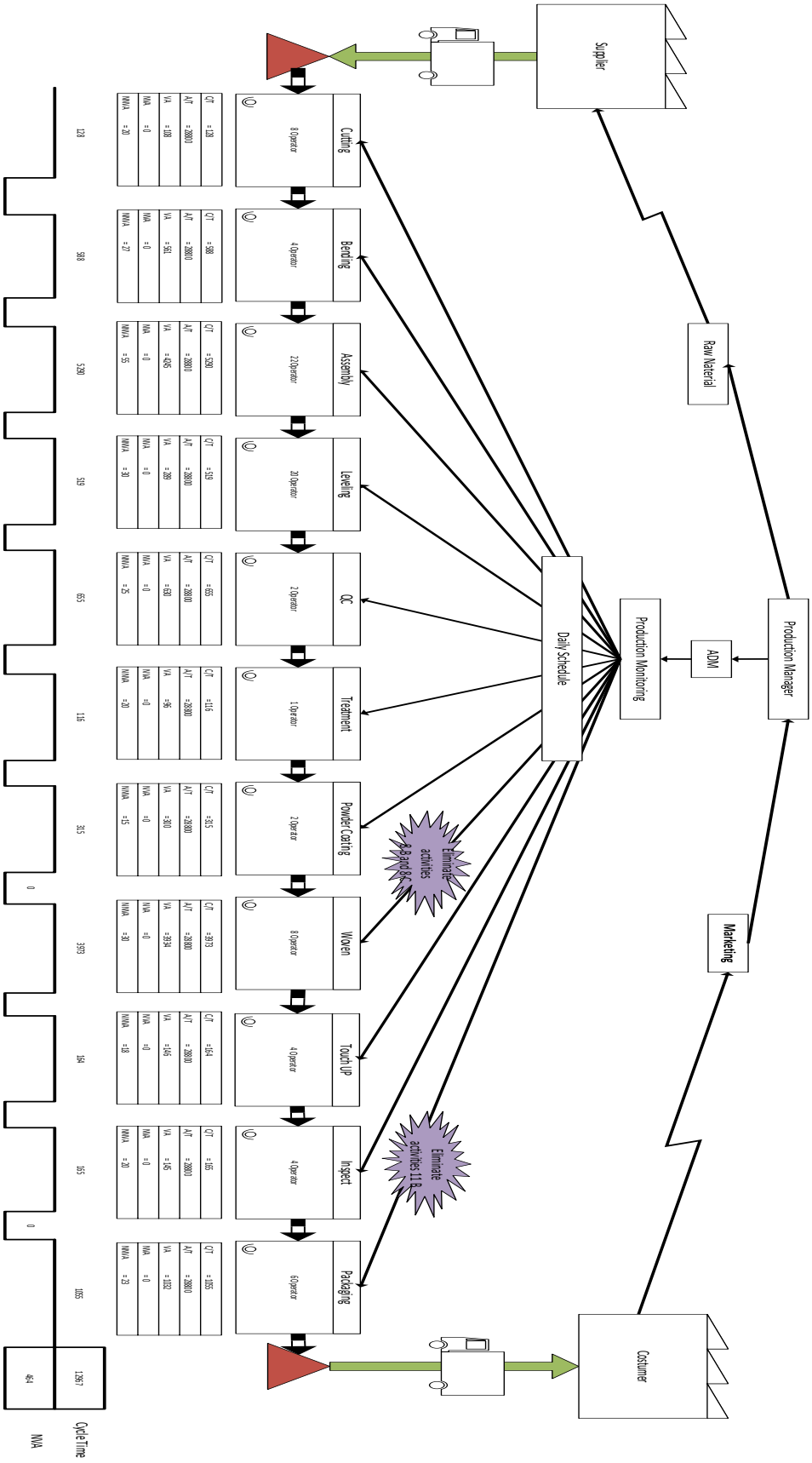

Figure 2. Future State Value Stream Mapping

Based on the analysis conducted, the recommendation for improvement that can be given to PT XYZ in the aluminium furniture production division focuses on reducing cycle time by eliminating processes or activities that do not add value. 2 processes do not add value, namely the weaving process and the packaging process. In the Weaving Process, there are 2 Non-Value Added (NVA) activities including taking weaving materials with transportation waste consuming 188 seconds covering a distance of 6 meters and tidying weaving materials with delay waste consuming 156 seconds. Then, there is 1 activity in the packaging process, which is taking packaging materials with transportation waste consuming 120 seconds covering a distance of 8 meters. Here are the improvement recommendations that minimize cycle time waste at PT XYZ:

a. Establishing performance standards for each production process.
b. Providing an Operation Process Chart (OPC) for each operator or trusted third party to understand the steps of each production process.
c. Implementing layout changes as depicted in Figure 3 and Figure 4.

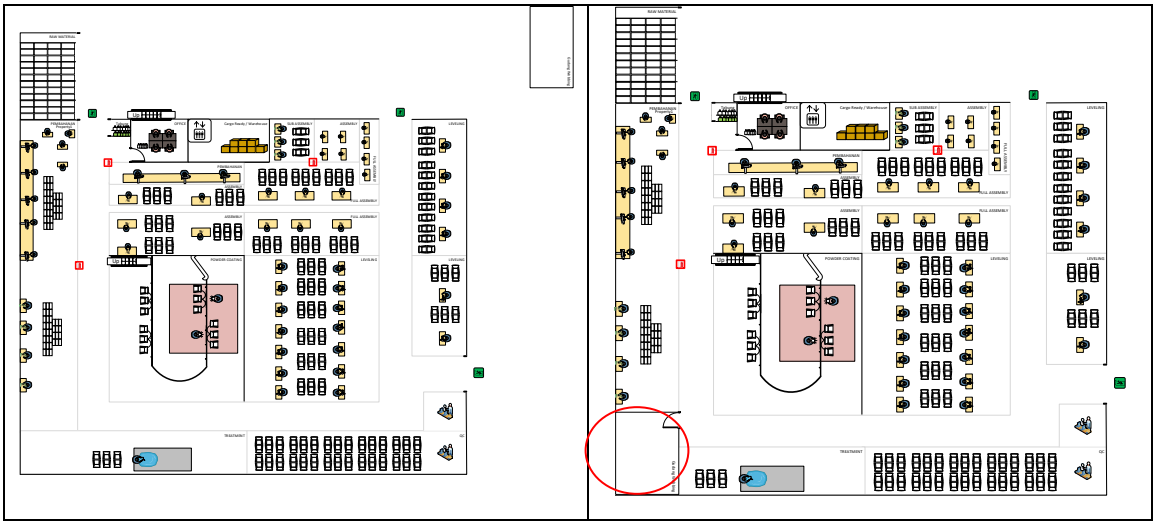

Figure 3. Current (left) and Proposed (right) Layout Floor 1

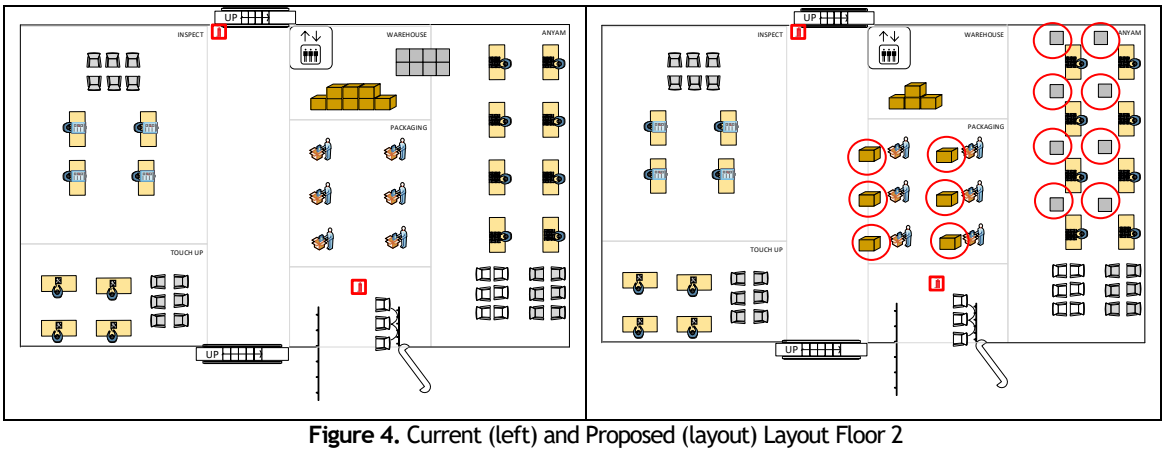

Figure 4. Current (left) and Proposed (layout) Layout Floor 2

Production layout improvements were made to minimize cycle time, with the red-marked areas indicating the regions changing the production floor layout. On the first floor, it is recommended to relocate the webbing warehouse from outside the production floor to inside. Then, on the second floor, changes are made to the packaging and weaving sections, where temporary storage space is provided at each workstation to accommodate woven materials and packaged goods, aiming to eliminate the activities of retrieving woven materials (8B), organizing woven materials (8C), and retrieving packaging materials (11B).

4. Conclusion

It is known that there are two potential sources of waste in the production of Porto Dining Chair, which are identified in the weaving and packaging processes. Waste in the weaving process occurs due to operator movement when taking unnecessary weaving materials, and there is also a process of tidying up weaving

materials, both of which take a total of 344 seconds. Waste in the packaging process is related to operator movement when taking packaging materials, which takes 320 seconds. The material flow from the beginning to the end of the Porto Dining Chair product includes cutting, bending, assembly, leveling, QC, treatment, powder coating, weaving, touch-up, inspection, and packaging. The total time required for all these processes is 13,432 seconds. The potential impact after the proposed changes is a reduction in production time by 464 seconds by eliminating processes 8B, 8C, and 10B.

References

1. Afif, A., & Purwaningsih, R. (2018). *ANALISIS WASTE PADA INDUSTRI MEBEL DENGAN MENGGUNAKAN PENDEKATAN LEAN MANUFACTURING Studi Kasus: CV. JATI MAS SEMARANG*.
2. Batwara, A., Sharma, V., Makkar, M., & Giallanza, A. (2023). Towards smart sustainable development through value stream mapping – a systematic literature review. In *Heliyon* (Vol. 9, Issue 5). Elsevier Ltd. https://doi.org/10.1016/j.heliyon.2023.e15852
3. Busert, T., & Fay, A. (2019). Extended Value Stream Mapping Method for Information Based Improvement of Production Logistics Processes. *IEEE Engineering Management Review*, *47*(4), 119–127. https://doi.org/10.1109/EMR.2019.2934953
4. Deshkar, A., Kamle, S., Giri, J., & Korde, V. (2018). Design and evaluation of a Lean Manufacturing framework using Value Stream Mapping (VSM) for a plastic bag manufacturing unit. *Materials Today: Proceedings*, *5*(2), 7668–7677. https://doi.org/10.1016/j.matpr.2017.11.442
5. Gasperz, V., & fontana, A. (2011). Lean Six Sigma For Manufacturing and Service Industries. Bogor: Vinchiristo Publication.
6. Gaspersz, V. (2007). Lean Six Sigma for manufacturing and service industries. Jakarta: Gramedia Pustaka Utama.
7. Hines, P., Rich, N., Bicheno, J., Brunt, D., Taylor, D., Butterworth, C., & Sullivan, J. (1998). Value Stream Management. *The International Journal of Logistics Management*, *9*(1), 25–42. https://doi.org/10.1108/09574099810805726
8. Hardianza, D. A. (2016). *IMPLEMENTATION OF LEAN MANUFACTURING METHOD VALUE STREAM MAPPING IN PT.X*.
9. Kasanah, Y. U., & Suryadhini, P. P. (2021). Identifikasi Pemborosan Aktivitas di Lantai Produksi PSR Menggunakan Process Activity Mapping dan Waste Assessment Model. *Jurnal INTECH Teknik Industri Universitas Serang Raya*, *7*(2), 95–102. https://doi.org/10.30656/intech.v7i2.3880
10. Kundgol, S., Petkar, P., & Gaitonde, V. N. (2019). Implementation of value stream mapping (VSM) upgrading process and productivity in aerospace manufacturing industry. *Materials Today: Proceedings*, *46*, 4640–4646. https://doi.org/10.1016/j.matpr.2020.10.282
11. Lee, J. K. Y., Gholami, H., Saman, M. Z. M., Ngadiman, N. H. A. Bin, Zakuan, N., Mahmood, S., & Omain, S. Z. (2021). Sustainability-Oriented Application of Value Stream Mapping: A Review and Classification. In *IEEE Access* (Vol. 9, pp. 68414–68434). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/ACCESS.2021.3077570
12. Lee, Q., & Snyder, B. (2007). *The strategos guide to value stream and process mapping*.
13. Liker, Jeffrey K. (2014). Der Toyota Weg: 14 Managementprinzipien des weltweit erfolgreichsten Automobilkonzerns. German: Finanzbuch Verlag.
14. Muhammady, Z. F. F. (2020). *i Minimasi Cycle Time Proses Produksi Mebel Berdasar Pendekatan Lean Manufacturing Dengan Menggunakan Metode Value Stream Mapping (VSM)*.
15. Pusdatin Kemenperin. (2022). *prev-peran strategis dan potensi penguatan industri furnitur*. 3. 5.
16. Q. Liu and H. Yang. (2020). "An Improved Value Stream Mapping to Prioritize Lean Optimization Scenarios Using Simulation and Multiple-Attribute Decision-Making Method," in IEEE Access, vol. 8, pp. 204914-204930. doi: 10.1109/ACCESS.2020.3037660.
17. Satao, M. S. (2012). Enhancing waste reduction through lean manufacturing tools and techniques, a methodical step in the territory of green manufacturing. International Journal of Research in Management and Technologiy, 2249 – 9563.
18. Susilawati, A., Darji, T., Agusti, I., & Sarwar, M. (2021). Mechanical and Aerospace-Science and Engineering-30 th. *Journal of Ocean*, *65*(1), 31–35. www.isomase.org.,

19. Ristyowati, T., Muhsin, A., Putri, D., & Nurani, P. (2017). *Jurnal Optimasi Sistem Industri MINIMASI WASTE PADA AKTIVITAS PROSES PRODUKSI DENGAN KONSEP LEAN MANUFACTURING (Studi Kasus di PT. Sport Glove Indonesia)*. *10*.
20. Turseno, A., Bhayangkara Jaya, U., Raya Perjuangan, J., Utara, B., & Jawa Barat, B. (2018). PROSES ELIMINASI WASTE DENGAN METODE WASTE ASSESSMENT MODEL & PROCESS ACTIVITY MAPPING PADA DISPENSING. *Journal Industrial Manufacturing*, *3*(1), 45–50.
21. Zamroni, S., & Mundadi, E. (2017). *Info Komoditi Furnitur*.