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Boosting productivity through lean manufacturing efficiency in furniture Small and Medium Enterprises (SMEs)

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ABSTRACT

A furniture manufacturer, a Small and Medium Enterprise (SME) whose main product is wooden chairs, has experienced problems in its manufacturing process. There are products that do not meet the desired size. The purpose of this research is to identify the most dominant waste through Borda weight calculations, determine the tools used in Value Stream Analysis Tools (VALSAT), find the root causes of the problems, and provide improvement suggestions using a fishbone diagram, as well as prioritize improvement suggestions using the Analytic Hierarchy Process (AHP). The research results using Borda weighting found that the most dominant waste was defect waste with a weight of 0.29. The VALSAT tool selected was Process Activity Mapping (PAM) with a score of 5.94. Improvement suggestions based on the fishbone diagram include work supervision, scheduling equipment and machinery maintenance, raw material checks, the creation of standard operating procedures (SOPs), and human resources training. The improvement suggestion prioritized based on the AHP results was the creation of standard operating procedures (SOPs) with a weight of 0.500. The difference in Process Cycle Efficiency increased from the previous 71% to 76% after the improvements.

1. Introduction

The furniture industry is inseparable from the production process, which goes directly from raw materials to finished products. In carrying out the production process, there are several things to consider, starting from the quality of raw materials, equipment, production time, transportation, and human resources, all of which greatly influence the production results. Producing a product often involves several problems that arise due to waste. Waste is an activity that does not add value. In the production process, if there is waste, follow-up actions are needed to minimize or even eliminate it to improve the efficiency of a process that affects the performance of an industry [1], [2]. Waste in the production process will lead to an increase in lead time, thus reducing production output and resulting in products that are not in line with the desired target when delivered. The furniture industry is an industry that processes raw materials or semi-finished materials such as wood, rattan, and other natural materials into finished products, thereby adding value and providing greater benefits to users. In carrying out the production process, it is necessary to determine the production factors used in the process so that it can run efficiently and the resulting production yields optimal results.

A small and medium enterprise (SME) is a furniture manufacturer that specializes in producing wooden products, particularly wooden chairs. This SME adopts the Make to Order approach, manufacturing items based on customer demands. Faced with intensifying competition and a rising volume of customer requests, the SME must continuously enhance and assess its production processes to optimize productivity. In one production cycle, this wooden chair manufacturing process requires approximately 3 hours to produce 1 wooden chair with a workforce of 2 individuals. The daily production time needed is 8 hours. The production process of the wooden chair consists of several stages, including planing, measurement and shaping, cutting, sanding, assembly, padding, sanding 2, and finishing with varnish.

Based on interviews and direct, several problems were identified in its production process. One of them is the repetitive task of transferring wood to multiple stations. This occurs because operators manually handle the transfer, leading to back-and-forth movements and unnecessary actions during

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production. As a result, production time is prolonged. For instance, in May, there were orders for 28 chairs, but only 25 were completed. In June, there were orders for 21 chairs, but only 18 were completed, and in July, there were orders for 16 chairs, but only 15 were completed. This discrepancy arises from some products not meeting the customer's desired dimensions, leading to rework by the workers and causing delays in delivery to the customers.

The problem causes production time to increase, and workers quickly become tired, as seen from workers stretching during the production process due to having to rework the products. Additionally, the raw materials are not in good condition, with findings of bent wood and cracked wood. These issues have a significant impact on productivity and profits, necessitating efforts to minimize the arising waste.

Waste, anything that doesn't add value, extends beyond discarded materials. It broadly encompasses resources like time, energy, and workspace [3], [4]. Lean Manufacturing is an approach that can be used to address wastefulness in companies, thereby reducing production lead time [5]. One of the tools that can be used in lean manufacturing is VALSAT. In the application of VALSAT, a weight value is needed, which will be multiplied by the multiplier value in the VALSAT matrix [6]. Weighting using VALSAT is for the selection of detailed mapping tools based on the wastefulness that occurs. In this study, to obtain the weight value, the Borda method is used. The Borda method can be used to determine the priority of which waste to address first by using a questionnaire to relevant departments [7].

This research builds on the work of [8] and [9] who explored implementing Lean Manufacturing using Value Stream Mapping and Value Stream Analysis Tools (VALSAT) in the sugar industry. The aim of this research is to identify types of waste and propose improvements to minimize waste in the sugar cane processing process. Based on the results of Process Activity Mapping (PAM), the sugar cane processing activities can be categorized as follows: 15 activities in Operations, 13 activities in Transportation, 6 activities in Inspection, and 3 activities in Delay. Storage consists of 2 activities. Process Activity Mapping (PAM) results also indicate a lead time reduction from 1212.07 minutes to 1176.23 minutes. Value Stream Mapping can further minimize time spent on transportation, inspection, and delay activities. Research results show waiting time and inappropriate processes contribute the most to production waste. Improvement recommendations include reducing processing times and implementing regular machine maintenance.

The Borda method is used because it can consolidate every decision, resulting in a single decision based on individual alternative rankings. The Analytic Hierarchy Process (AHP) is then employed to further aid decision-making. This method excels at prioritizing factors within decision-making processes [10], [11]. Essentially, AHP is used to find the ranking or priority order of various alternatives in solving a problem.

To identify the most dominant waste in the wooden chair production process, this study utilizes the Borda method for ranking. Subsequently, specific tools from the Value Stream Analysis Tools (VALSAT) will be chosen. Based on the obtained waste weight, the most dominant waste will be identified, and its root causes will be analyzed using a fishbone diagram [12], [13]. Finally, the Analytic Hierarchy Process (AHP) will be used to weigh recommendations for improvement in the production process, aiming to minimize waste occurrence.

2. Material and method

This research was conducted at a small and medium-sized enterprise (SME) operating in the furniture sector. Data collection involved gathering information on the company, production layout, processes, activities, observation times, and production data over a 3-month period.

Data processing included tests for data adequacy and consistency. Cycle times were calculated based on observation data. Seven types of waste were identified and weighted using the Borda method (questionnaires were used to assess waste dominance). Value Stream Analysis Tools (VALSAT) were then chosen based on the waste weighting. A value stream map was created to understand information flow in the production process. A fishbone diagram helped identify root causes of problems. Finally, the Analytic Hierarchy Process (AHP) was used to develop and weigh alternative improvement proposals.

3. Results and discussions

An analysis of Table 1 reveals the sequence of waste weights in the wood chair production process, from most dominant to least dominant: Defect (0.29), Inappropriate Processing (0.21), Delay (0.14), Unnecessary Motion (0.14), Transportation (0.11), Unnecessary Inventory (0.07), and Overproduction (0.04). Therefore, defect is the most dominant waste in chair production process. The concept of Value Stream Analysis Tools (VALSAT) is used for selecting tools that will be used to further analyze waste.

This is done by multiplying the weighting from the Borda method by the scale available in the VALSAT Table 2. Table 2 indicates that Process Activity Mapping (PAM) is the most relevant tool for waste identification, with a score of 5.94. PAM is used to analyze all activities involved in wood chair production. The goal is to eliminate unnecessary activities, identify lead time, and determine potential process improvements for efficiency [6]. Below is a summary of grouping activities based on value-added activities (VA), non-value-added but necessary activities (NNVA), and non-value-added activities (NVA) [10]. From this grouping, it can be determined which activities are most dominant in the production line. Table 3 shows a total of 49 activities in the wood chair production process.

Table 1.
Borda weighting recap

Type of waste	Rangking							Final Score	Weight
	1	2	3	4	5	6	7		
Overproduction						1	1	1	0,04
Delay/Waiting				1		1		4	0,14
Transportation					1	1		3	0,11
Inappropriate Processing				2				6	0,21
Unnecessary Inventory					1		1	2	0,07
Unnecessary Motion					2			4	0,14
Defect			2					8	0,29
M	6	5	4	3	2	1	0	28	

Table 2.
Value Stream Analysis Tools (VALSAT)

Waste	Weight	VALSAT						
		PAM	SCRM	PVF	QFM	DAM	DPA	PS
Overproduction	0,04	L (0,04)	M (0,04)		L (0,04)	M (0,04)	M (0,04)	
Delay/Waiting	0,14	H (0,14)	H (0,14)	L (0,14)		M (0,14)	M (0,14)	L (0,14)
Transportation	0,11	H (0,11)						
Inappropriate Processing	0,21	H (0,21)		M (0,21)	L (0,21)		L (0,21)	L (0,21)
Unnecessary Inventory	0,07	M (0,07)	H (0,07)	M (0,07)		H (0,07)	M (0,07)	
Unnecessary Motion	0,14	H (0,14)	L (0,14)					
Defect	0,29	L (0,29)			H (0,29)			
Total	100%	5,94	2,15	0,98	2,86	1,17	0,96	0,35
Rank		1	3	5	2	4	6	7

Table 3.
Current Process Activity Mapping (PAM)

No	Activities	Amount	Time (Seconds)	Percentage
1	Operation	18	5956	55%
2	Transportation	12	497	5%
3	Inspection	12	316	3%
4	Storage	0	0	0
5	Delay	7	4122	38%
6	Total	49	10891	100%
7	VA	18	7767	71%
8	NVA	13	276	3%
9	NNVA	17	2848	26%
10	Total	49	10891	100%

These activities are classified as: 18 Value-Added (7767 seconds), 13 Non-Value Added (276 seconds), and 17 Necessary but Non-Value Added (2848 seconds). Based on the current Process Activity Mapping (PAM), these activity categories are used to calculate the Process Cycle Efficiency (PCE) [14]. The Process Cycle Efficiency (PCE) of 71% indicates a significant opportunity for improving system efficiency. This suggests eliminating non-value-added activities can lead to substantial improvements.

A Value Stream Mapping tool is used to create a current state map, visualizing the flow of materials and information in the current production process. This map highlights the relationship between value-added activities and identifies waste within the existing process. Fig. 1 shows that the value-added time wooden chair production is 7767 seconds, while the lead time is 10891 seconds.

To identify the root causes of defects, a fishbone diagram is then used, considering human, machine, environment, method, and material factors [15]. Fig. 2 illustrates the identified mitigation improvements for each root cause of defects: job supervision, scheduling equipment and machine maintenance, raw material checking, creating standard operating procedures, and conducting human resource training.

The next step is to determine proposed improvements that will be prioritized for addressing defect reduction. The Analytical Hierarchy Process (AHP) method is one method used for decision-making by considering various criteria. In the AHP method, there are several stages: forming a hierarchy, pairwise comparison matrix, normalization, and consistency testing. Here is the hierarchy of this research, presented in Fig. 3 and Tables 4, 5, 6, 7, and 8.

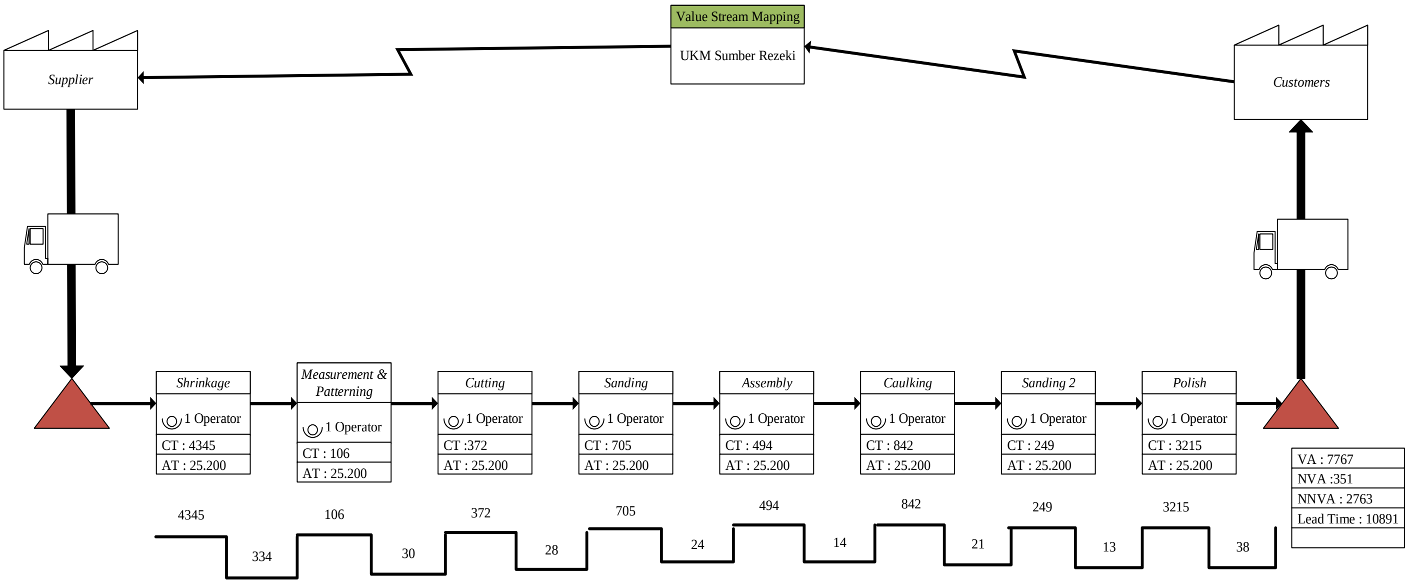

Figure 1. Current Value Stream Mapping

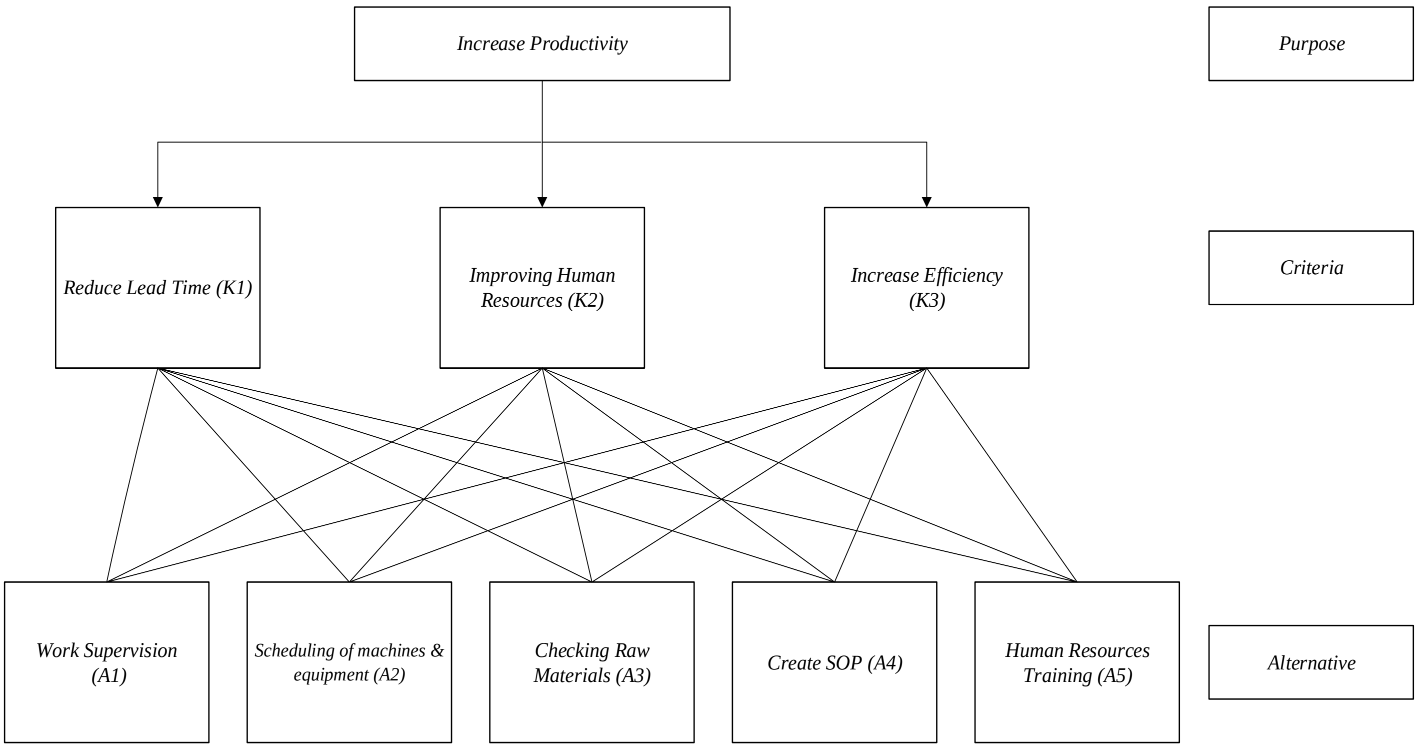

Figure 2. The structure of AHP

Fig. 3 depicts the hierarchy for this study, with the objective of enhancing productivity. The criteria used to evaluate improvement alternatives include reducing lead time, improving human resources, and increasing efficiency. The AHP methodology is employed by administering questionnaires to experts. In this study, the questionnaire is filled out by 2 respondents: the SME owner and the production head. The step of the pairwise matrix is presented in Table 4.

Based on the completed stages, the pairwise comparison indicates that reducing lead time is the top priority criterion with a score of 0.640. Among the alternatives, creating standard operating procedures emerged as the highest priority with a score of 0.500.

Table 4.
Pairwise criteria matrix

	Time	Human Resources	Efficiency
Time	1	3	5
Human Resources	1/3	1	3
Efficiency	1/5	1/3	1
Total	1,5	4,3	9

Table 5.
Alternative pair matrices

	Supervision	Scheduling	Checking	SOP	HR Training
Supervision	1	1	¼	1/5	3
Scheduling	1	1	¼	1/5	5
Checking	4	4	1	1/3	3
SOP	5	5	3	1	9
HR Training	1/3	1/5	1/3	1/9	1
Total	11,3	11,2	4,8	1,8	21

Table 6.
Normalization criteria

	Time	HR Training	Efficiency	Amount	Priority	Eigen
Time	0,667	0,698	0,556	1,92	0,64	0,96
HR	0,2	0,233	0,333	0,766	0,255	1,098
Efficiency	0,133	0,07	0,111	0,314	0,105	0,943
Total	1	1	1	3	1	3

Tabel 7.
Alternative normalization

	Supervision	Scheduling	Checking	SOP	HR Training	Amount	Priority
Supervision	0,088	0,089	0,052	0,111	0,143	0,484	0,097
Scheduling	0,088	0,089	0,052	0,111	0,238	0,579	0,116
Checking	0,354	0,357	0,208	0,167	0,134	1,229	0,246
SOP	0,442	0,446	0,625	0,556	0,429	2,498	0,5
HR Training	0,027	0,018	0,063	0,056	0,048	0,21	0,042
Total	1	1	1	1	1	5	1

Tabel 8.
Consistency test

No	Variable	Criteria	Alternative
1	Lambda Max	3,004	5,352
2	CI	0,00018	0,088
3	RI	0,58	1,12
4	CR	0,00031	0,078

Table 9.
Future Process Activity Mapping (PAM)

No	Activities	Amount	Time (Seconds)	Percentage
1	Operation	17	5938	58%
2	Transportation	11	306	3%
3	Inspection	1	53	1%
4	Storage	0	0	0
5	Delay	7	3913	38%
6	Total	36	10210	100%
7	VA	18	7767	76%
8	NVA	0	0	0
9	NNVA	17	2443	24%
10	Total	36	10210	100%

The Consistency Ratio (CR) for both the criteria (0.00031) and alternatives (0.078) falls well below the threshold of 0.1, indicating a high level of consistency in the data used for the AHP analysis [8]. This suggests that the results can be considered reliable for informing improvement decisions.

The Process Cycle Efficiency (PCE) value has increased to 76%, indicating a significant improvement in production efficiency at SME XYZ compared to the previous value of 71%. This aligns with the principle that a higher PCE value signifies a more efficient process.

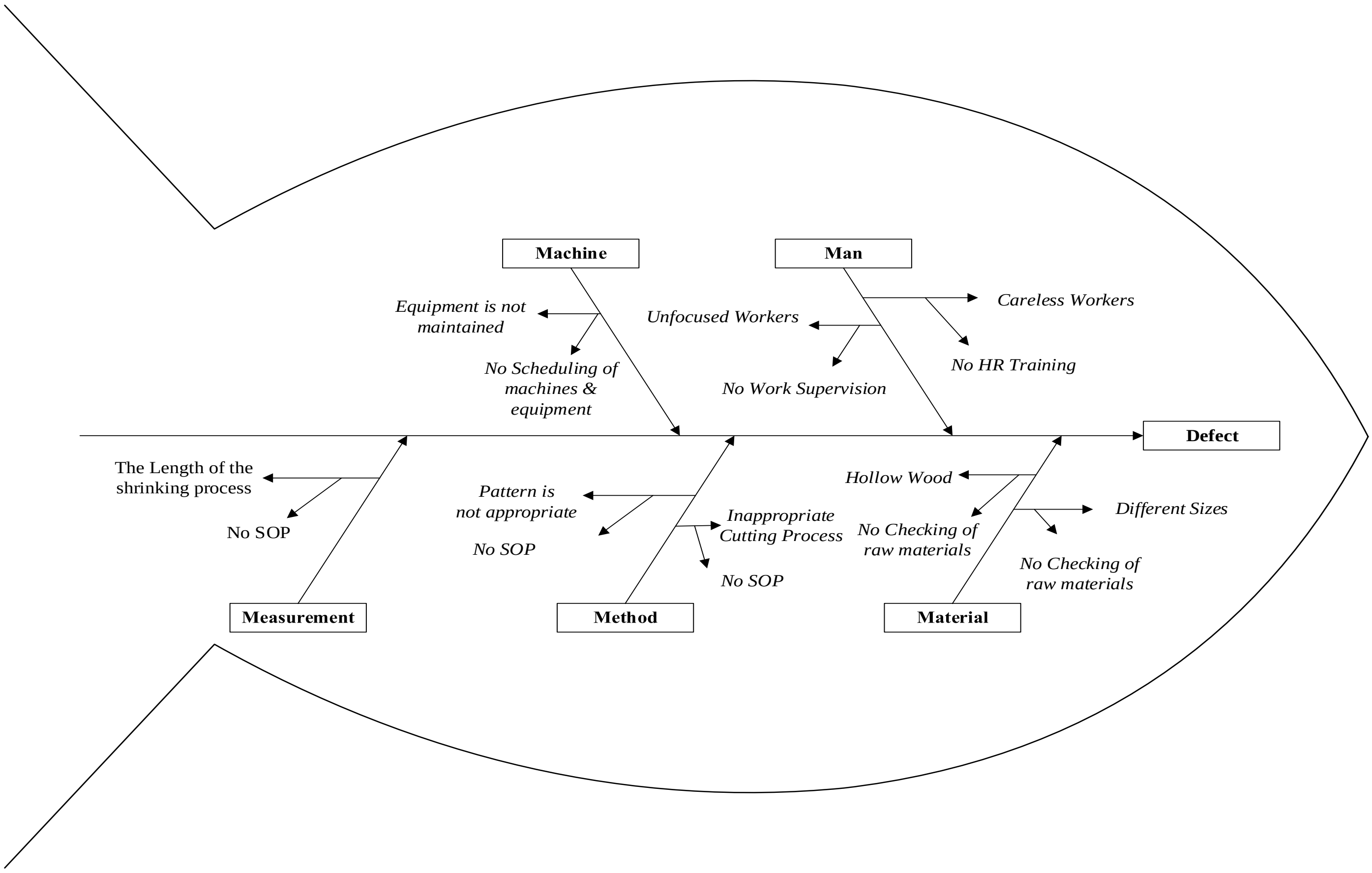

Figure 3. Fishbone diagram

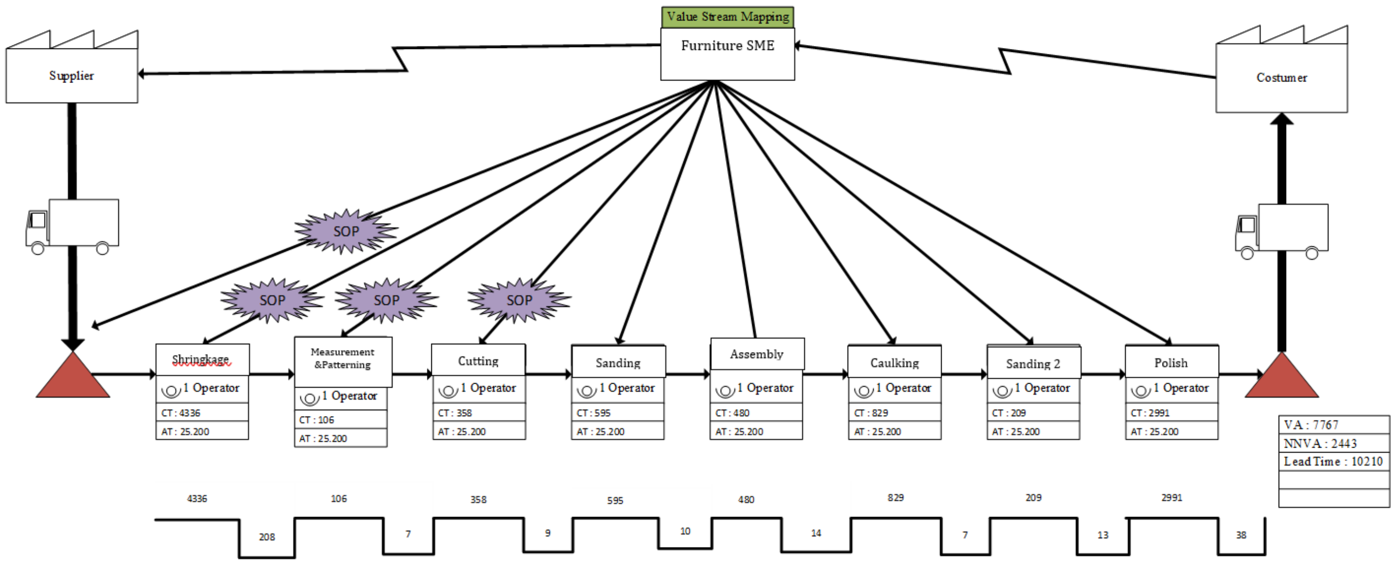

Figure 4. Future state Value Stream Mapping

Future state mapping is a visualization of material and information flow in the production process after improvements. Value Stream Mapping is a tool used to visualize the entire system, which serves to depict the relationship between value-added time [9]. With this production process mapping, waste in the existing process can be easily identified. Fig. 4 shows the future state value stream mapping for wooden chair production. The total value-added time remains at 7767 seconds, indicating efficient use of production time. However, the lead time has been reduced to 10210 seconds, reflecting an improvement in overall process efficiency. To minimize waste defects, a standard operating procedure (SOP) has been proposed. As outlined in the future state value stream map, this SOP emphasizes stricter raw material checks at key stations: planing, measurement, sanding, and cutting.

4. Conclusions

The Borda method identified waste defects as the most significant and influential type of waste in the wooden chair production process at a furniture manufacturer. Process Activity Mapping (PAM), a tool within the Value Stream Analysis Tools (VALSAT) framework, determined a weight of 5.94 for this waste category.

To minimize waste in the production process, the fishbone diagram identified several improvement strategies: work supervision, scheduled equipment and machine maintenance, raw material inspection, SOP creation, and human resources training. The AHP method then prioritized these actions, highlighting the creation of Standard Operational Procedures (SOP) as the most critical intervention.

Declaration statement

Evi Febianti: **Conceptualization, Methodology, Software and Resources.** Yusraini Muharni: **Supervision, Visualization, Investigation.** Desi Ramdhani: **Writing-Original Draft, Data Processing.** Shanti Kirana Anggraeni: **Editing, Supervision.**

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The authors report there are no competing interests to declare.

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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