

Evaluation of the Skin Cracker Production Process at Skin Cracker SMEs

Ahmad Syafruddin Indrapriyatna^{1*}, Reinny Patrisina², Asi Siva Dea³, Nahda Sulasi⁴,
Yonithri Sherlyna⁵

^{1,2} Department of Industrial Engineering, Faculty of Engineering, Universitas Andalas Padang
Kampus Lamau Manis, Padang, 25164

Email: ahmads@eng.unand.ac.id, reinny@eng.unand.ac.id

^{3,4,5} Alumni of the Department of Industrial Engineering, Faculty of Engineering, Universitas Andalas
Padang

Kampus Lamau Manis, Padang, 25164

Email: 2110931023_asi@student.unand.ac.id, 2110931015_nahda@student.unand.ac.id,
2110931007_yonithri@student.unand.ac.id

ABSTRACT

XYZ SME is a small and medium enterprise (SME) based in Padang, West Sumatra, specializing in traditional skin crackers (locally known as kerupuk jangek a traditional cowhide-based cracker). The company faces critical challenges related to hygiene and production inefficiencies, particularly delays during drying and frying stages, as well as inefficient material flow due to a suboptimal facility layout. This study employs Lean Manufacturing tools to identify and reduce production waste. The methodology incorporates the Waste Assessment Model (WAM) to quantify waste types, Value Stream Mapping (VSM) to visualize the production process, and Value Stream Analysis Tools (VALSAT) to prioritize improvement strategies. WAM analysis identified transportation (21.277%), inventory (17.021%), and waiting time (14.894%) as the most significant waste categories. The initial Process Cycle Efficiency (PCE) was measured at 41.82%. Improvement proposals included enhanced GMP practices through training, supervision, and infrastructure upgrades, as well as production efficiency measures such as layout redesign, improved worker discipline, and the use of cost-effective machinery. These interventions led to a projected PCE of 95.24%, indicating substantial improvements in workflow efficiency.

Keywords: Lean Manufacturing, Waste Assessment, Value Stream Mapping, Food Safety, SME Productivity

Introduction

Small and medium enterprises (SMEs) play a critical role in Indonesia's economic development, contributing significantly to employment and local innovation in traditional food processing sectors. One such SME is XYZ, located in Padang City, which produces traditional cowhide crackers with a daily production capacity of approximately 40 kilograms. The enterprise relies on cowhide sourced from local slaughterhouses in Alahan Panjang, Solok Regency, and seasonal supplies during the Eid al-Adha festival. Despite the cultural and economic importance of this product, the enterprise faces significant operational challenges that impede its efficiency and scalability.

A major concern is the suboptimal handling and storage of cowhide, which is currently conducted without standardized procedures. The hides are stored in piles without protective layers, dividers, or implementation of a first-in-first-out (FIFO) system. This condition accelerates quality degradation due to excessive pressure and moisture, especially in the absence of adequate ventilation or temperature regulation. Furthermore, direct exposure to floor surfaces and open-air environments increases the risk of contamination by microorganisms and insects. Studies have shown that poor storage conditions are a major contributor to microbial spoilage and food safety risks in traditional food supply chains [1], [2].

These issues are particularly critical for traditional food SMEs, which typically operate under significant constraints in production space, capital availability, and sanitation infrastructure. Limited floor space often forces raw materials and semi-processed products to be stored close to processing areas, increasing contamination risks. At the same time, financial constraints limit investments in advanced storage systems and hygienic processing equipment, making practical, low-cost improvement strategies especially important.

In addition to raw-material handling issues, the production process also suffers from notable workflow inefficiencies. Specifically, significant delays occur during the drying stage, which must be completed before advancing to the *latuah* stage—where dried cowhide is soaked in oil for an extended period to enhance its puffiness. Observations reveal that waiting time constitutes a critical source of waste in this process. According to lean manufacturing principles, such as those outlined by [3], [4], [5] Waiting for waste can significantly reduce production efficiency, increase labor costs, and raise operational costs.

These operational inefficiencies, if left unaddressed, can reduce the competitiveness and profitability of SMEs. Identifying and reducing waste—such as excessive material handling, process repetition, and prolonged idle time—are essential steps toward improving production flow and product quality [6]. Accordingly, many traditional food SMEs in Indonesia would benefit from systematic approaches to waste identification and process optimization, yet practical implementation remains limited.

Unlike previous studies that apply individual lean tools such as VSM or WAM independently, this research integrates WRM, WAQ, VSM, and VALSAT in a sequential analytical framework. This integration allows the study to (1) identify dominant waste categories using WRM, (2) quantify their relative significance through WAQ, and (3) prioritize improvement actions using VALSAT.

This study aims to identify and analyze non-value-added activities in the production process of an XYZ SME using lean manufacturing tools. Specifically, the research focuses on identifying dominant waste categories, analyzing process flow, and proposing practical recommendations to reduce production delays and quality risks. The findings are expected to contribute to the growing literature on lean implementation in traditional food SMEs and provide actionable insights for similar enterprises facing comparable challenges.

Accordingly, the study evaluates how dominant wastes interact within the production system and assesses the effectiveness of lean-based interventions in improving production efficiency and hygiene conditions in traditional food SMEs. This study addresses the following research questions:

RQ1. What waste categories dominate the production process in XYZ SME, and how do these wastes interact within the production system?

RQ2. Which lean-based interventions should be prioritized to improve production efficiency and hygiene conditions in traditional food SMEs?

To address these research questions, this study adopts a structured lean manufacturing framework that integrates multiple analytical tools to systematically identify, quantify, and prioritize production waste. The research approach and analytical procedures are described in the following section. This study differentiates itself by explicitly integrating interaction-based waste analysis (WRM) with perception-based quantification (WAQ) within a unified decision-support framework tailored for SME contexts.

Research Methods

To address the research questions, this study adopts a structured lean manufacturing approach to systematically identify, analyze, and reduce waste in the production process of XYZ SME. The research framework integrates several complementary lean tools, including the Waste Assessment Model (WAM), Waste Relationship Matrix (WRM), Waste Assessment Questionnaire (WAQ), Value Stream Mapping (VSM), and Value Stream Analysis Tools (VALSAT), within a sequential analytical structure. This integrated approach enables the study to capture both qualitative insights and quantitative measurements of waste, ensuring a comprehensive evaluation of production inefficiencies and supporting the development of targeted improvement strategies.

Lean Manufacturing Framework

Lean manufacturing is a systematic approach aimed at eliminating waste and maximizing value from the customer's perspective. Originating from the Toyota Production System, lean thinking is based on five core principles: value identification, value stream mapping, flow creation, pull system implementation, and continuous improvement [7]. In this context, waste refers to any activity that does not add value to the product, including overproduction, waiting, transportation, overprocessing, excess inventory, motion, and defects [8].

The identification and elimination of these wastes are essential to improving productivity, reducing operational costs, and enhancing product quality, particularly in SMEs with limited resources [6].

Lean Tools for Waste Identification and Analysis

To systematically analyze waste in the production process, this study employs several complementary lean tools. Value Stream Mapping (VSM) is used to visualize the flow of materials and information, enabling the identification of both value-added and non-value-added activities [9]. The Waste Assessment Model (WAM) provides a structured framework for identifying and prioritizing waste sources in manufacturing systems [10]. Within this framework, the Waste Relationship Matrix (WRM) is applied to analyze interdependencies among different types of waste, allowing the identification of waste interactions and root causes [11], while the Waste Assessment Questionnaire (WAQ) is used to quantify waste based on structured questionnaires and weighted scoring, integrating worker perceptions with analytical results [12].

Furthermore, Value Stream Analysis Tools (VALSAT) extend VSM by offering detailed analytical tools, such as process activity mapping, to diagnose inefficiencies and support improvement decisions [13]. In addition, work time measurement is applied to determine standard processing times and evaluate productivity levels within the system [14]. To support root cause analysis, the Fishbone Diagram is utilized to systematically categorize contributing factors into manpower, methods, machines, materials, measurement, and environment [15].

Previous studies have generally applied these tools independently. However, limited research integrates WRM-based interaction analysis with WAQ-based quantitative validation in traditional food SMEs. Therefore, this study combines these tools into a sequential framework to enhance diagnostic accuracy and decision support.

Research Procedure

The research was conducted through several systematic stages:

1. **Preliminary Study and Problem Identification**

Initial observations were conducted to understand the production system, identify operational issues, and define research objectives.

2. **Data Collection**

Data were collected through:

- Direct observation of production activities
- Structured interviews with SME owners and workers
- Measurement of processing times and workstation dimensions
- Assessment of sanitation practices

3. **Waste Identification and Analysis**

Waste identification was carried out using:

- **WRM** to analyze relationships between waste types
- **WAQ** to quantify waste based on weighted questionnaire responses

4. **Process Mapping and Analysis**

The production process was mapped using **VSM** to identify value-added and non-value-added activities and calculate Process Cycle Efficiency (PCE).

5. **Tool Selection and Detailed Analysis**

Based on WAQ results, **VALSAT** was used to determine the most appropriate analytical tool for further investigation.

6. **Improvement Design**

Improvement proposals were developed based on identified dominant wastes and were analyzed using lean principles

7. **Future state value stream mapping (VSM)**

A future state VSM was developed to evaluate the impact of the proposed improvements by comparing process efficiency before and after implementation, particularly in terms of Process Cycle Efficiency (PCE)..

These steps collectively form a sequential lean manufacturing framework that links waste identification, quantitative analysis, tool selection, and performance evaluation within a unified decision-support structure. Research procedure flowchart can be seen in Figure 1.

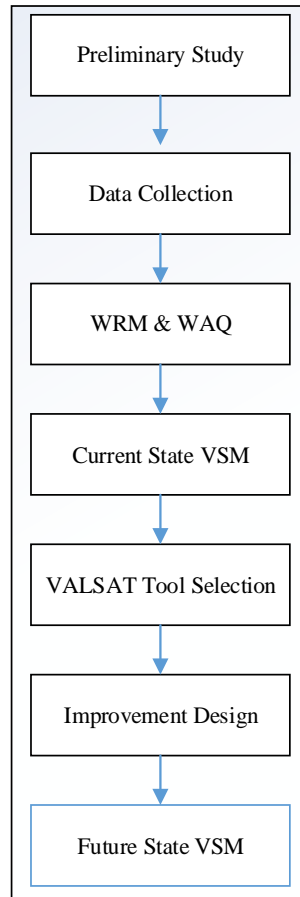


Figure 1. Research procedure flowchart

Results and Discussion

Data Collection

Data were collected through direct observation and structured interviews at the SME, focusing on production flow, material handling, sanitation, and time studies, complemented by a validated questionnaire incorporating the Waste Relationship Matrix (WRM), Waste Assessment Questionnaire (WAQ), and sanitation metrics. The WRM and WAQ assessments involved four respondents: the SME owner and three experienced production workers. Respondents were selected using purposive sampling based on their operational involvement and knowledge of the production process. This triangulation ensured the integration of both operational data and worker insights [10]. Although the number of respondents is limited, they represent key operational roles and possess comprehensive knowledge of the production process, ensuring the reliability of the assessment.

Data Processing

This study contributes methodologically by structuring multiple lean diagnostic tools—including VSM, WRM, WAQ, and VALSAT-based analysis—into a sequential analytical framework. Unlike studies that apply VSM or WAM independently, the proposed approach links waste interaction analysis (WRM), quantitative validation (WAQ), tool prioritization (VALSAT), and layout redesign within a single decision-support flow.

Current Value Stream Mapping

The current state value stream mapping (VSM) reveals both value-adding and non-value-adding activities throughout the production process. Processing time was 180 minutes, with value-added time contributing 75.3 minutes, resulting in a Process Cycle Efficiency (PCE) of 41.82%. Activities such as waiting for drying and manual transportation were identified as significant bottlenecks. Figure 2 shows the current Value Stream Mapping.

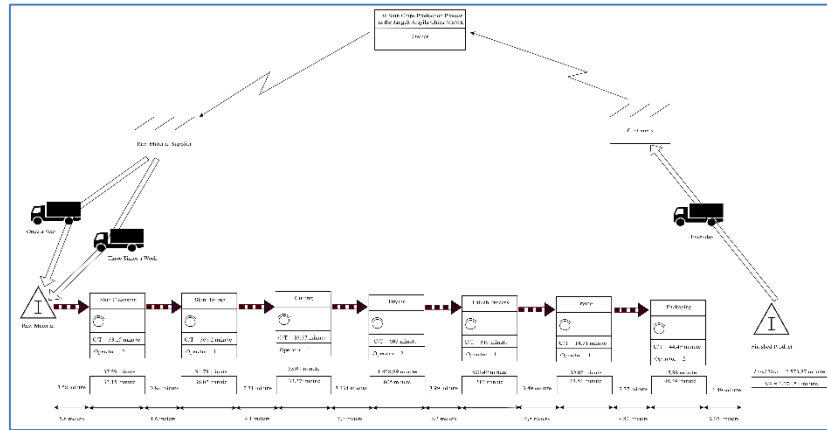


Figure 2. Current value stream mapping

Waste Relationship Matrix (WRM)

WRM scores were computed based on pairwise evaluations between waste types using expert judgment. The most impactful wastes were: Waiting (19.1%), Inventory (16.9%), and Transportation (14.6%). 'Others' (49.4%) includes Overproduction, Over-processing, Defects, and Motion. Table 1 shows the final values of the Waste Relationship Matrix (WRM). The notation F/T represents From/To relationships between waste categories, while Score indicates the cumulative interaction value.

Table 1. Waste Relationship Matrix (WRM)

F/T	O	I	D	M	T	P	W	Score	%
O	10	6	2	4	6	0	2	30	16.854
I	2	10	2	2	6	0	0	22	12.360
D	4	2	10	2	4	0	4	26	14.607
M	0	2	4	10	0	6	4	26	14.607
T	2	4	2	4	10	0	8	30	16.854
P	2	2	2	4	0	10	6	26	14.607
W	2	4	2	0	0	0	10	18	10.112
Score	22	30	24	26	26	16	34	178	100.000
%	12.360	16.854	13.483	14.607	14.607	8.989	19.101	100.000	

Therefore, the WRM results provide an initial indication of the relative influence of different waste categories in the production system. To further validate and quantify the dominance of these wastes, the analysis is complemented by the Waste Assessment Questionnaire (WAQ), which incorporates WRM-based weighting with questionnaire responses from production workers.

Waste Assessment Questionnaire (WAQ)

WAQ scores were calculated by multiplying each question's Likert-scale score by its normalized WRM weight. The WRM analysis first produced a percentage score representing the relative influence of each waste category. These percentages were then normalized and used as weighting factors in the WAQ calculation. The WAQ value for each waste category was obtained by multiplying the normalized WRM weight by the average Likert-scale response for the corresponding questionnaire items. This approach ensures that questionnaire responses not only reflect workers' perceptions of waste occurrence but are also adjusted for the systemic influence of each waste type identified through the WRM analysis. Table 2 shows the results of the WAQ calculation.

Table 2. WAQ calculation results

Parameter	O	I	D	M	T	P	W	Total
Y _j	0.308	0.377	0.321	0.301	0.397	0.304	0.358	
F _j	0.021	0.021	0.020	0.021	0.025	0.013	0.019	
Y _j Final	0.006	0.008	0.006	0.006	0.010	0.004	0.007	0.047
% Y _j Final	12.766	17.021	12.766	12.766	21.277	8.511	14.894	

Transportation waste was identified as the most dominant category at 21.277%, followed by inventory waste (17.021%) and waiting waste (14.894%). Over-processing was the least significant

category at 8.511%. To facilitate comparison between the WRM and WAQ results, the rankings from both analyses are summarized in Table 3.

Table 3. Comparison of WRM and WAQ Waste Prioritization

Waste Category	WRM (%)	WRM Rank	WAQ (%)	WAQ Rank	Final Priority Basis
Overproduction	12.360	2	12.766	4	–
Inventory	16.854	2	17.021	2	WAQ
Defects	13.483	6	12.766	6	–
Motion	14.607	4	12.766	5	–
Transportation	14.607	4	21.277	1	WAQ
Processing	8.989	7	8.511	7	–
Waiting	19.101	1	14.894	3	WAQ

Table 3 presents a comparison between the waste rankings obtained from the WRM and WAQ analyses. As shown in Table 3, the WRM results indicate that waiting waste has the highest interaction score (19.101%), suggesting a strong influence on other waste categories within the production system. However, the WAQ results provide a different prioritization when worker perceptions and WRM-based weighting are combined. Based on the WAQ analysis, transportation waste emerged as the most dominant category (21.277%), followed by inventory waste (17.021%) and waiting waste (14.894%). Therefore, these three waste categories were selected as the primary focus for the subsequent VALSAT analysis.

Value Stream Analysis Tools (VALSAT)

The VALSAT analysis was conducted to determine the most appropriate tool for analyzing the dominant wastes identified in the production process. VALSAT tool selection was performed by matching the dominant waste characteristics identified through WAQ with the VALSAT tool relevance matrix. Each tool was assigned a weighted score based on its suitability for addressing the prioritized wastes, and the tool with the highest aggregate score was selected for further analysis. Based on this procedure, Process Activity Mapping (PAM) was most suitable, with a score of 5.874 out of 7. PAM revealed that 32.26% of activities were value-adding, 48.39% were necessary but non-value-adding, and 19.35% were pure waste. The classification of PAM activities is shown in Table 4.

Table 4. The classification of PAM activities

Activities	Number of Activities	Percentage
Value Added (VA)	10	32.26%
Non Value Added (NVA)	6	19.35%
Necessary Non-Value Added (NNVA)	15	48.39%
Total	31	100%

The sequential integration of WRM, WAQ, and VALSAT therefore provides a structured analytical pathway that links waste interaction diagnosis, quantitative waste prioritization, and improvement tool selection within a single lean decision-support framework.

Improvement Proposals

To reduce Waiting Waste, a tray dryer and a spinner machine are proposed to shorten drying and oil removal times, respectively (see Figure 3).



Figure 3. Proposed tray dryer and spinner machine

For Transportation Waste, redesigning the layout using the Activity Relationship Chart (ARC) (Figure 4) and introducing a hand trolley (Figure 5) are suggested.

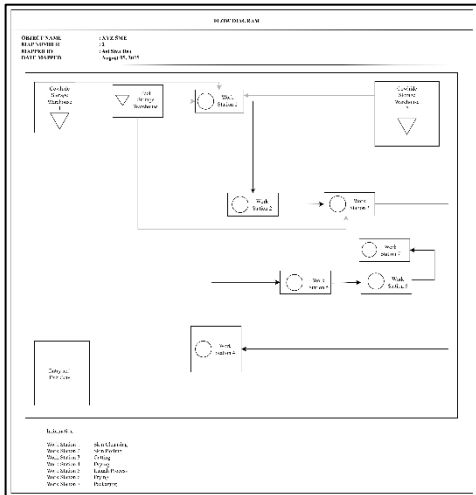


Figure 4. Layout redesign result



Figure 5. Hand trolley

For Inventory Waste, improvements include shelf optimization, real-time tracking via barcode systems, and demand forecasting models. The design of the storage cabinet for cowhide raw materials is shown in Figure 6.

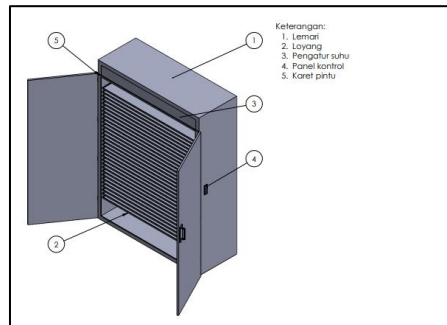


Figure 6. Storage cabinet for cowhide raw materials

Future Value Stream Mapping

Post-improvement VSM shows that process time is reduced to 120 minutes, with 114.3 minutes as value-added time, resulting in a PCE of 95.24%. This value represents the projected performance of the proposed future-state scenario based on the redesigned production flow and lean improvement recommendations. The projected PCE value of 95.24% is derived from estimated cycle time reductions after eliminating identified non-value-added activities. These estimates are based on the technical specifications of the proposed tray dryer and spinner machines and assuming stable operating conditions without additional bottlenecks. This indicates a substantial productivity increase. However, initial investment, employee retraining, and layout changes are critical success factors. Future VSM can be seen in Figure 7.

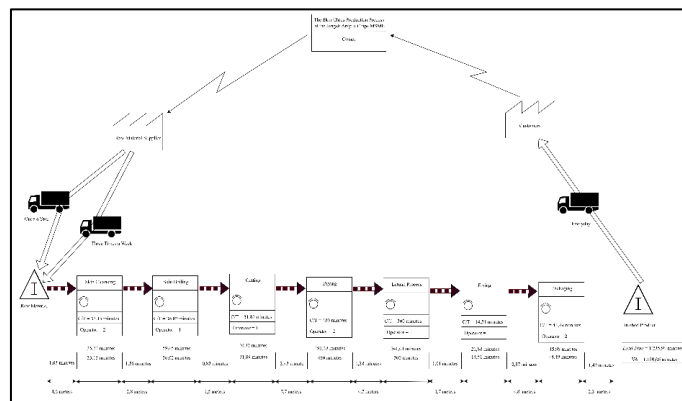


Figure 7. Future value stream mapping

Although the proposed improvements have not yet been implemented, the recommendations are supported by time measurements, waste prioritization analysis, and lean manufacturing principles. Future studies should incorporate experimental validation or pilot implementation to confirm the projected performance improvements.

A simple sensitivity discussion was conducted by considering possible variations in drying time, which is highly dependent on environmental conditions. The analysis indicates that moderate fluctuations in drying duration would not significantly alter the relative improvement trend observed in the proposed scenario. Although the projected PCE appears significantly high, it reflects an ideal scenario under controlled assumptions and should be interpreted as a potential performance ceiling rather than an immediately achievable outcome.

Conclusion

This study identified the dominant sources of waste in the production process of an XYZ SME using the Waste Assessment Model (WAM), supported by the Waste Relationship Matrix (WRM), the Waste Assessment Questionnaire (WAQ), and the Value Stream Analysis Tools (VALSAT). The results reveal that transportation, inventory, and waiting are the most critical waste categories, with transportation waste accounting for the most at 21.277%, followed by inventory at 17.021% and waiting at 14.894%. These percentages are derived from the WAQ-based prioritization, which integrates WRM weighting with questionnaire responses. The dominance of transportation waste reflects inefficiencies in material flow caused by suboptimal facility layouts, inadequate material-handling systems, and limited transport resources, which collectively increase lead times and reduce production system stability. The proposed improvements also significantly increase Process Cycle Efficiency (PCE) from 41.82% to 95.24% under the modeled future state conditions.

These findings emphasize that improving layout configuration and material handling systems is not merely an operational adjustment but a strategic priority for enhancing productivity in SME manufacturing systems. The study contributes by providing a structured, practical diagnostic approach that supports managerial decision-making in prioritizing waste-reduction initiatives.

However, this study is limited to waste identification and prioritization without quantitatively evaluating the economic impact and implementation feasibility in real operational settings. The findings are context-specific and may require adaptation when applied to other SMEs with different production characteristics. Therefore, future research should incorporate cost-benefit analysis to assess the feasibility and financial implications of both layout redesign and material handling improvements. Further studies are encouraged to expand the scope of analysis by including additional lean waste categories, such as overproduction, overprocessing, and underutilization of human resources. Moreover, additional analytical tools, such as Root Cause Analysis (RCA), would enable a deeper, more systematic identification of inefficiencies, thereby supporting the development of a comprehensive, sustainable waste minimization strategy. This study provides a foundation for developing systematic, data-driven waste-reduction strategies in SME manufacturing systems.

References

- [1] A. Rampal and S. P. Yamini Kanti, "Good Manufacturing Practice (GMP): History, structure and its significance," *International Journal of Drug Regulatory Affairs*, vol. 8, no. 4, pp. 66–72, Dec. 2020, doi: 10.22270/ijdra.v8i4.439.
- [2] V. Geraldo *et al.*, "Implementation of good manufacturing practices (GMP) to improve the quality of smoked fish (*Scombercolias*)," *Heliyon*, vol. 10, 2023, doi: 10.1016/j.heliyon.2024.e27401.
- [3] I. Litvaj, "Lean management, lean principles, lean manufacturing," *University of Žilina*, 2023, doi: 10.26552/tech.C.2023.1.12.
- [4] J. Fortuny-Santos, P. Ruiz-de-Arbulo-López, E. Zubeltzu-Jaka, and I. Lujan-Blanco, "Lean manufacturing and environmental performance: A meta-analytic approach," *International Journal of Lean Six Sigma*, vol. 16, 2024, doi: 10.1108/IJLSS-11-2023-0190.
- [5] D. Meilani and H. A. Samat, "Lean Implementation in Indonesian Small and Medium Enterprises: A Systematic Literature Review," *Jurnal Optimasi Sistem Industri*, vol. 23, no. 1, pp. 29–45, 2024, Accessed: Aug. 17, 2025. [Online]. Available: <https://josi.ft.unand.ac.id/index.php/josi/article/view/5>
- [6] S. Rahayu, P. E. Yuliana, and Kelvin, "Penggunaan Metode VALSAT dan WAM untuk Mereduksi Limbah Pada Pabrik Timah di Pasuruan (The Use of VALSAT and WAM Methods to Reduce Waste at

- a Tin Factory in Pasuruan),” *Journal of Information System, Graphics, Hospitality and Technology*, vol. 6, no. 1, 2024, doi: 10.37823/insight.v6i1.335.
- [7] Y. Bouazza and A. Lajjam, “Contribution of Lean Manufacturing on environmental performance in Moroccan Industry,” *Logistic and Operation Management*, vol. 2, no. 2, 2023, doi: 10.31098/lomr.v2i2.1921Contribution of.
- [8] F. Pomalia, I. Iftadi, and R. D. Astuti, “Waste analysis of fuselage assembly in panelization group of the 117th NC212i aircraft,” *Jurnal Sistem dan Manajemen Industri*, vol. 4, no. 1, pp. 61–71, Jul. 2020, doi: 10.30656/jsmi.v4i1.2187.
- [9] R. Brilianto and N. P. Waluyowati, “Analisis Proses Produksi Dengan Value Stream Mapping Pada Industri Manufaktur (Production Process Analysis with Value Stream Mapping in the Manufacturing Industry),” *Jurnal Kewirausahaan dan Inovasi*, vol. 3, no. 4, pp. 1095–1103, Nov. 2024, doi: 10.21776/jki.2024.03.4.14.
- [10] Y. B. Irawan and K. Fitriani, “Waste Assessment Model (WAM): How Does the Company Assess the Waste?,” *Jurnal Sains dan Teknologi Lingkungan*, vol. 16, no. 2, pp. 54–68, 2024, Accessed: Aug. 17, 2025. [Online]. Available: <https://journal.uui.ac.id/JSTL/article/view/33980/17200>
- [11] M. A. Khan, Khatri. Awaiz, and H. B. Marri, “Applications of Waste Relations Matrix (WRM) in Lean Wastes Identification,” in *e 11th Annual International Conference on Industrial Engineering and Operations Management*, 2021. Accessed: Aug. 17, 2025. [Online]. Available: <https://www.ieomsociety.org/singapore2021/papers/1269.pdf>
- [12] Suharjo and S. Sudiro, “Pengurangan Pemborosan Pada Proses Produksi Dengan Menggunakan Wrm, Waq Dan Valsat Pada Sistem Lean Manufaktur (Studi Kasus Pada Produksi Setrika Lisrik) (Waste Reduction In The Production Process By Using Wrm, Waq And Valsat In The Lean Manufacturing System (Case Study on Electric Iron Production)),” *TEKNOBIZ*, vol. 8, no. 2, 2019, doi: 10.35814/teknobiz.v8i2.896
- [13] A. J. Pical, Y. Desrina, and D. Andrian, “Lean Manufacturing Analysis: Using WAM and VALSAT to Reduce Waste in the Plastic Sack Finishing Process at PT Surya Plastindo,” *Engineering Headway*, vol. 18, pp. 153–162, 2025, Accessed: Aug. 17, 2025. doi: 10.4028/p-nKM8rh
- [14] B. Lukács and M. Antal, “The reduction of working time: definitions and measurement methods,” *Sustainability: Science, Practice and Policy*, vol. 18, no. 1, pp. 710–730, 2022, doi: 10.1080/15487733.2022.2111921
- [15] A. Kumah *et al.*, “Cause-and-Effect (Fishbone) Diagram: A Tool for Generating and Organizing Quality Improvement Ideas,” *Global Journal Quality Safafety Healthcare*, vol. 7, no. 2, pp. 85–87, 2024, Accessed: Aug. 17, 2025. [Online]. Available: <https://pmc.ncbi.nlm.nih.gov/articles/PMC11077513/>