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Enhancing Production Efficiency Through Lean Manufacturing: A Case Study at Yellow Noodle SMIs in Padang, Indonesia

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Abstract

The industrial sector in Indonesia is urged to improve efficiency and competitiveness through the implementation of lean manufacturing. However, challenges such as entrenched work culture and mindset often hinder success, resulting in persistent waste. Waste refers to non-value-added activities that increase costs and reduce productivity. Small and Medium Industries (SMIs) contribute significantly to Indonesia's economy, including Yellow Noodle SMI. This study aims to identify dominant types of waste in the production process and recommend improvements. The methods used include Value Stream Mapping (VSM), Process Activity Mapping (PAM), Fishbone Diagram, and Failure Mode and Effect Analysis (FMEA). Current State VSM shows a Process Cycle Efficiency (PCE) of 48.32%. PAM highlights a high proportion of non-value-added activities. The Fishbone Diagram reveals causes such as equipment limitations, inefficient layout, and poor worker scheduling. FMEA results show that waiting and transportation are the most critical wastes. Improvement suggestions include installing a drying machine, redesigning the production layout, and optimizing worker schedules. These improvements are projected to increase the PCE to 91.66% in the Future State VSM, supporting the company in reducing waste and enhancing production efficiency.

Keywords
Efficiency, Lean Manufacturing, Small and Medium Industries, Waste and Yellow Noodle.

1. Introduction
Lean manufacturing is a production management approach that emphasizes the efficient transformation of raw materials into finished goods by minimizing waste throughout the production process (Rahardjo et al., 2023). The concept was developed by Taiichi Ohno, Eiji Toyoda, and Shingeo Shingo through the Toyota Production System (TPS) as a post-World War II effort to revitalize Japan's manufacturing industry (Ponda et al., 2022). The core objective of lean manufacturing is to enhance productivity by eliminating waste and optimizing resource utilization (Phangestu et al., 2023).

Despite its proven benefits, many industries in Indonesia have yet to adopt lean manufacturing practices due to cultural and mindset barriers (Hizam et al., 2024). As noted by Hartini (2022), limited understanding and improper application of lean tools also hinder its implementation. Consequently, many industrial companies still face non-value-added activities, inefficient resource use, and increased production costs (Lamatinulu, 2022). Waste in production refers to activities that do not add value, resulting in unnecessary consumption of materials, time, labor, and capital (Moh & Enny, 2023). There are eight commonly identified types of waste: transportation, inventory, motion, waiting, overproduction, overprocessing, defects, and non-utilized talent (Arunizal et al., 2024).

Reducing waste is crucial for improving production efficiency and lowering operational costs (Giari & Asep, 2023). This issue is especially relevant in Indonesia's Small and Medium Industries (SMI), which accounted for 99.7% of total industrial units in 2023, contributing significantly to the national economy (Ministry of Industry, 2024). According to Ministerial Regulation No. 64/M-IND/PER/7/2016, SMIs are businesses with investments between 1 to 15 billion IDR and a workforce of up to 20 employees.

This study focuses on Yellow Noodle SMIs in Padang, West Sumatra, Indonesia. Observations revealed several critical types of waste in the production process, including transportation inefficiencies due to suboptimal layout, excessive motion caused by repetitive manual tasks, delays due to worker availability and weather conditions, and frequent product defects leading to rework. For example, delays in drying due to rain have resulted in moldy noodles, while improper stacking during processing has caused breakage and increased scrap volume. Such inefficiencies have led to missed production targets and reduced profitability. Previous research has demonstrated that lean manufacturing can significantly reduce production time and increase Process Cycle Efficiency (PCE) in various food and manufacturing industries (Syaher & Setiafandari, 2024; Afrilia et al., 2024; Prasmita et al., 2024; Nugroho & Faritsy, 2024). Therefore, this study applies lean manufacturing tools to identify and analyze waste in the yellow noodle production process, aiming to propose actionable improvements that enhance efficiency and performance.

2. Methods

This research adopts a quantitative and qualitative approach to identify and eliminate waste in the yellow noodle production process. The data collected through observation, interviews, and time measurements were processed using several lean manufacturing tools. The stages are as follows:

1) Development of Current Value Stream Mapping (CVSM)
The first step involves creating a CVSM using data related to material and information flow, machine and labor usage, production times, and transfer times between workstations. Before inputting production times into the CVSM, uniformity and adequacy tests were conducted to ensure data reliability. From the CVSM, lead time and value-added time are calculated, followed by determining the Process Cycle Efficiency (PCE) of the current production process.

2) Current Process Activity Mapping (CPAM)
Based on the CVSM, activities are classified using CPAM into three categories: value-added (VA), non-value-added (NVA), and necessary but non-value-added (NNVA). In addition, each task is categorized as an operation, transportation, inspection, storage, or delay.

3) Waste Identification
Waste is identified based on results from VSM, CPAM, direct observation, and brainstorming sessions. The identification refers to the eight types of waste in lean manufacturing: transportation, inventory, motion, waiting, overproduction, overprocessing, defects, and unutilized talent.

4) Root Cause Analysis using Fishbone Diagram
A fishbone diagram is used to identify the root causes of waste. This step involves discussions with the owner and workers to analyze contributing factors, which are categorized into man, method, materials, machine, measurement, and environment.

5) Determining Critical Waste using Failure Mode and Effect Analysis (FMEA)
After identifying the causes of waste, FMEA is used to prioritize them based on their level of risk. Questionnaires are distributed to assess severity, occurrence, and detection levels. The Risk Priority Number (RPN) is then calculated to identify the most critical waste that negatively impacts the production process.

6) Proposing Improvement Solutions

Based on the highest RPN values, improvement proposals are formulated to eliminate critical waste and improve production efficiency.

7) Future Process Activity Mapping (FPAM)

Based on the expected impact of proposed improvements, the CPAM is updated into a Future Process Activity Mapping to evaluate the reduction in non-value-added and unnecessary activities.

8) Future State Value Stream Mapping (FVSM)

A FVSM is developed based on the anticipated improvements. This map helps visualize changes in lead time and value-added time, and calculates the expected PCE after improvements in the production process.

3. Results and Discussion

3.1 Development of Current Value Stream Mapping (CVSM)

Value Stream Mapping (VSM) has been widely adopted as a lean tool to visualize, analyze, and improve the flow of materials and information in various production and service contexts. Introduced by Rother and Shook (1999) as part of the Toyota Production System, VSM helps distinguish value-adding from non-value-adding activities, while Hines and Rich (1997) emphasized its role in eliminating waste during lean transformations. Its effectiveness has been demonstrated in heavy industries (Abdulmalek & Rajgopal, 2007) and adapted for healthcare settings (Singh et al., 2011), though researchers such as Arbós (2002) and Riezebos et al. (2009) have noted limitations when applied to highly variable and dynamic production systems. In line with these applications, VSM is used in this study to visually represent the flow of the yellow noodle production process—from the procurement of raw materials to the delivery of finished products to customers. The Current Value Stream Mapping (CVSM) illustrates the existing production system of yellow noodles, as shown in Figure 1.

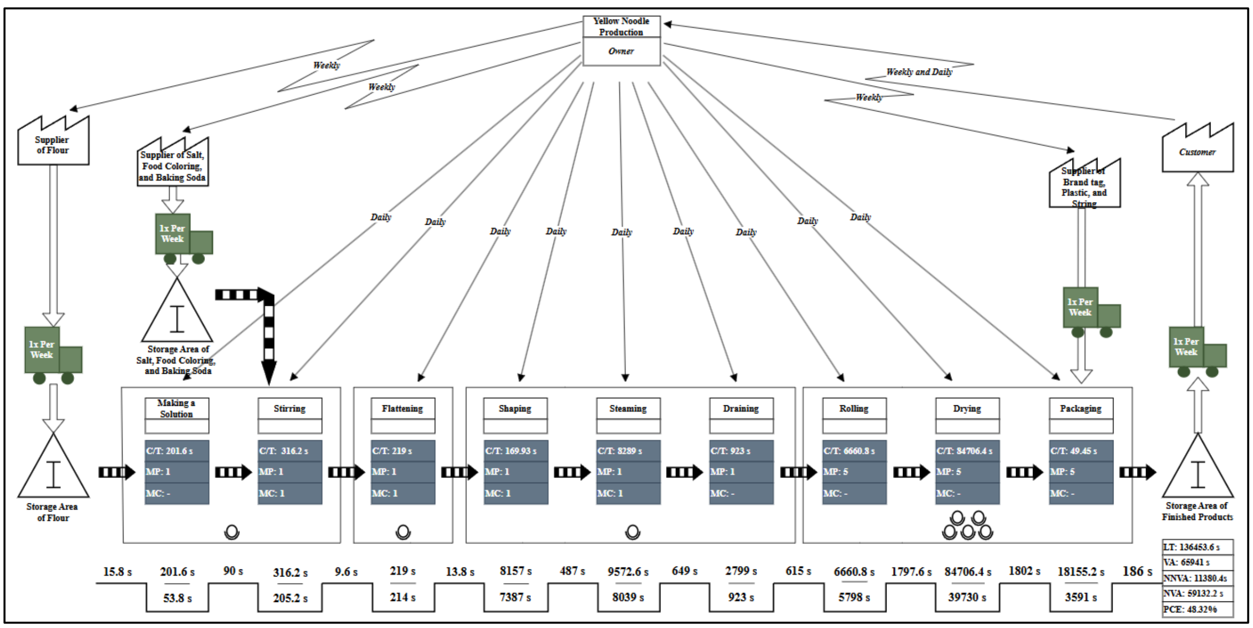

Figure 1. Current Value Stream Mapping

According to the CVSM, the company sources its raw materials from several suppliers. Flour is ordered once a week from a dedicated supplier. Salt, food coloring, and baking soda are obtained from another supplier located at a single site, also ordered weekly. Packaging materials such as brand tags, plastic, and string are ordered from a third supplier, again with a weekly frequency. Customers typically collect the finished products directly from the facility every day or once a week, depending on their purchasing schedule.

The yellow noodle production process consists of nine stages. Based on CVSM analysis, the total lead time is 136,453.6 seconds, with 65,941 seconds classified as value-added (VA) time. This results in a Process Cycle

Efficiency (PCE) of 48.32%. According to Gaspersz (2007), a process is considered lean if its PCE is at least 30%. Therefore, the current process can be categorized as lean; however, there is still room for improvement.

3.2 Current Process Activity Mapping (CPAM)

Current Process Activity Mapping (CPAM) is a method used to provide a comprehensive overview of all activities involved in the current production process. These activities are categorized into three types: Value-Added (VA) activities, which directly contribute to the transformation of raw materials into finished products; Non-Value-Added (NVA) activities, which do not contribute value and should be eliminated; and Necessary but Non-Value-Added (NNVA) activities, which do not add value but are currently necessary due to existing system constraints.

Each activity in the CPAM is also classified according to its type using standard lean symbols: Operation (O), Transportation (T), Inspection (I), Delay (D), and Storage (S). In addition to activity classification, CPAM includes information on the machines/tools used, transport distances, and processing times. Two types of time data are recorded: (1) Lead time, which reflects the sequence of operations in series, where the total duration equals the lead time; (2) Actual total time, which represents the real-time duration including parallel processes in production.

The summary of activity types is presented in Table 1. It shows that NNVA activities account for the highest proportion, with 58.93% of total activities but only 8.44% of the total production time. VA activities constitute 33.93% of activities and represent the highest time contribution at 48.32%. NVA activities represent only 7.14% of all activities but consume 43.23% of the total time, indicating substantial inefficiencies.

Table 1. Summary of activity types in CPAM

Activity type	**Number of activities**	**% of activities**	**Time (sec)**	**% of time**
Value Added (VA)	19	33.93%	65,941.0	48.32%
Non-Value Added (NVA)	4	7.14%	58,993.8	43.23%
Necessary Non-Value Added (NNVA)	33	58.93%	11,518.8	8.44%
Total	56	100%	136,453.6	100%

The classification of activities based on lean process elements is presented in **Table 2**. The majority of activities (55.36%) are operations, contributing to 49.36% of total time. Transportation activities account for 37.50% of tasks, but only 7.40% of time, indicating short-duration but frequent movement. Delays (5.36%) consume 12.90% of the time, while storage activities, though only 1.79% of total tasks, consume a significant 30.33% of time. No inspection activities were identified during the mapping.

Table 2. Summary of activity elements in CPAM

Activity element	**Number of activities**	**% of activities**	**Time (sec)**	**% of time**
Operation (O)	31	55.36%	67,359.8	49.36%
Transportation (T)	21	37.50%	10,100	7.40%
Inspection (I)	0	0.00%	0	0.00%
Storage (S)	1	1.79%	41,388	30.33%
Delay (D)	3	5.36%	17,605.8	12.90%
Total	56	100%	136,453.6	100%

From these results, it is evident that a large portion of time is consumed by non-productive activities such as storage and delay, which need to be minimized. The insights from CPAM will serve as the foundation for identifying waste and prioritizing improvement initiatives in the subsequent analysis stages.

3.3 Waste Identification

Waste identification was conducted by analyzing the results from the Current Value Stream Mapping (CVSM), Current Process Activity Mapping (CPAM), direct observations, and brainstorming sessions with stakeholders of yellow noodle SMIs. Through this process, five types of waste were identified in the yellow noodle production process: transportation, motion, waiting, overprocessing, and defect.

1. Transportation Waste

Transportation waste was identified in two key areas:

- The distance between the draining station and the three rolling station areas is significant. The farthest distance is 11.2 meters, with an average transportation time of 615 seconds.
- The distance between the stacked noodle drying trays and the rolling station is also excessive. The nearest distance is 12 meters, with an average retrieval time of 316 seconds.

2. Motion Waste

Motion waste was observed in several repetitive and inefficient worker movements:

- Workers frequently walk back and forth between the draining and rolling stations, approximately 10 times, with an average time of 615 seconds.
- Workers retrieve drying trays 10–15 times, with an average movement time of 307 seconds. The trays are also stacked at a height exceeding the worker's height (~180 cm), creating ergonomic risks.
- At the mixing station, workers clean up flour scrap 15 times, with each cleaning taking about 21.6 seconds.
- At the rolling station, workers collect broken noodles for rework, taking an average of 122.2 seconds per cleaning.
- Manual lifting of noodles occurs repeatedly from the rolling station to drying and from drying to packaging, with no material handling aids. The average movement times are 1,797.6 seconds (rolling to drying) and 1,802 seconds (drying to packaging).

3. Waiting Waste

Several delays were recorded throughout the production process:

- A delay before draining, where noodles were not immediately transferred after steaming, with an average waiting time of 1,283.6 seconds.
- A delay before rolling, due to the rolling station worker's absence after draining, resulting in 1,876 seconds of idle time.
- Delays in drying caused by the absence of sunlight at night and rainy weather, with average delays of 41,388 seconds.
- A delay before packaging, where noodles were not packaged immediately after drying, averaging 14,446.2 seconds.

4. Overprocessing Waste

Overprocessing was identified due to rework activities:

- Rework of broken noodles involves reintegrating them into the mixing process. Each rework adds 138.4 seconds of lead time and is performed eight times.
- Rework of moldy noodles requires soaking to remove mold before reintegration. Although soaking is done in parallel with drying and does not add to the lead time, the rework step still adds 138.4 seconds per cycle, also done eight times.

5. Defect Waste

Two major sources of product defects were identified:

- Broken noodles occur during the rolling process. These fragments are too small for the next process and must be reworked.
- Moldy noodles result from inadequate drying (not fully dried within three days). Moldy products pose health risks and cannot be sold to customers. These must also be reprocessed.

3.4 Root Cause Analysis using Fishbone Diagram

After identifying the types of waste present in the yellow noodle production process, the next step involves conducting a root cause analysis to determine the underlying factors causing these wastes. This was done using fishbone analysis, created through brainstorming sessions with the owner and workers of yellow noodle SMIs. The analysis is categorized by each identified type of waste.

1. Fishbone Analysis for Transportation Waste

The fishbone analysis for transportation waste aims to explore the reasons behind excessive movement, including the long distance between the draining station and the three rolling work areas, and the distant placement of noodle drying mats from the rolling station. This waste is mainly attributed to environmental factors. The primary causes of transportation waste include suboptimal production layout and underutilized workspace. Workers are accustomed to the current layout without considering transport efficiency, and available empty space near the production area is not utilized for drying mat placement, resulting in unnecessary movement.

2. Fishbone Analysis for Motion Waste
The fishbone analysis for motion waste identifies causes related to repetitive and unnecessary movements, such as workers walking back and forth to transport noodles, fetch drying mats, and clean scrap materials.

- Method: Motion waste results from the absence of material handling tools for transporting mats, and inefficient practices like placing drying mats randomly due to cramped workspace.
- Machine: The use of low-capacity sacks for noodle transport forces workers to make multiple trips. The lack of proper handling tools contributes to this inefficiency.
- Material: Scrap generation, such as broken noodles or undissolved flour lumps, arises from inadequate stirring processes and excessive handling, increasing unnecessary movement during cleaning.

3. Fishbone Analysis for Waiting Waste
The fishbone analysis for waiting waste explores delays during draining, rolling, drying, and packaging. The root causes stem from environmental and method-related factors.

- Environment: Drying is delayed by the absence of sunlight at night and rainy weather. Since drying relies on natural sunlight, these conditions extend the production cycle.
- Method: The delay before packaging primarily stems from a lack of synchronization between the drying and packaging processes. This issue arises due to the absence of a coordinated scheduling or pull system, limited availability of packaging workers immediately after drying, and the unpredictable duration of sun-based drying influenced by weather conditions. As a result, noodles often remain idle after drying, leading to inefficiencies and potential quality risks. Addressing this requires better process alignment and real-time communication between stages.

4. Fishbone Analysis for Overprocessing Waste
The fishbone analysis for overprocessing waste focuses on unnecessary rework, including reprocessing broken or moldy noodles. This waste is rooted in method-related factors.

- Method: Broken noodles are caused by repeated manual handling, and mold growth occurs due to insufficient drying caused by bad weather or exposure to rain. These lead to additional processing steps such as cleaning, soaking, and re-mixing, increasing total production time.

5. Fishbone Analysis for Defect Waste
The fishbone analysis for defect waste identifies causes of broken and moldy noodles. These defects originate from human and environmental factors.

- Human: Broken noodles result from workers repeatedly separating sticky noodles before rolling, which damages the noodle strands.
- Environment: Mold formation primarily results from excessively prolonged drying times, which are common during periods of cloudy or rainy weather. The complete dependence on direct sunlight, without the use of protective coverings or controlled environments, renders the drying process highly vulnerable to external conditions. When ambient humidity remains high and drying is delayed, moisture is retained in the noodles for extended periods—creating an ideal environment for microbial growth. Furthermore, direct exposure to rainwater during unexpected weather fluctuations accelerates spoilage by reintroducing moisture at a critical phase, compromising both product quality and safety.

3.5 Determining Critical Waste using Failure Mode and Effect Analysis (FMEA)

After identifying the root causes of waste through the fishbone diagram, a more in-depth analysis was carried out using the Failure Mode and Effect Analysis (FMEA) method. This method helps to determine which waste types have the most significant impact on the yellow noodle production process by calculating the Risk Priority Number (RPN). The RPN is calculated by multiplying three parameters: Severity (S) – the seriousness of the impact caused by the waste, Occurrence (O) – the frequency at which the cause of waste occurs, and Detection (D) – the ability of current controls to detect the waste. The FMEA questionnaire was completed by eight respondents, including the owner. Prior to filling in the questionnaire, all respondents were briefed on how to rate each parameter using a defined scoring guideline. The scores from all respondents were averaged to obtain representative values for each failure mode. The summarized results of the FMEA analysis are shown in Table 3.

Table 3. Summary of FMEA Analysis Results

Waste Type	**Potential Failure**	**Potential Effect of Failure**	**S**	**Potential Cause of Failure**	**O**	**Control**	**D**	**RPN**	**Suggested Improvement**
Transportation	Distance between draining station and other areas	Increased lead time	4.63	Poor layout	10	None	4.5	208.13	Layout improvement
	Distance between tray stack and rolling area	Increased lead time	4.25	Poor layout	10	None	4.5	191.25	Layout improvement
Motion	Back-and-forth movement carrying noodles	Increased lead time	4.63	Small-capacity sacks	10	None	2	92.50	Provide material handling tools
	Movement for drying trays	Increased lead time	4	Random tray placement	10	None	2	80.00	Layout improvement
	Scrap cleaning at mixing station	Increased lead time	2.13	Clumpy flour mix	10	Owner's warning	2	42.50	SOP and work instructions
	Scrap cleaning at rolling station	Increased lead time	1.88	Broken noodles	10	None	2	37.50	SOP and work instructions
	Back-and-forth movement during drying and packaging	Increased lead time	6	No handling tools for trays	10	None	2	120.00	Provide material handling tools
Waiting	Delay before draining	Increased lead time	6	Inefficient scheduling	10	None	2.5	150.00	Worker arrival scheduling
	Delay before rolling	Increased lead time	7	Inefficient scheduling	10	None	2.5	175.00	Worker arrival scheduling
	Delay before drying	Increased lead time	10	No sunlight (night)	10	None	2	200.00	Provide drying machine
				Rainy weather	8.63	None	2	172.50	Provide drying machine
	Delay before packaging	Increased lead time	9	Inefficient scheduling	10	None	2.5	225.00	Worker arrival scheduling

Overprocessing	Rework broken noodles	Increased lead time	2.5	Broken noodles	10	None	2	50.00	SOP and work instructions
	Rework moldy noodles	Increased lead time	5	Mold growth	9.25	None	2	92.50	Provide drying machine
Defect	Broken noodles	Rework	3.13	Repetitive movement while separating noodles	10	None	2	62.50	SOP and work instructions
	Moldy noodles	Rework	6.75	Drying delay due to bad weather	8.75	None	2	118.13	Provide drying machine
				Rainwater exposure for 3 days	7.5	None	2	101.25	Weather-proof drying area

Wastes with an RPN greater than 150 are classified as *high* or *very high* risk and therefore require immediate corrective action. Based on the results, the seven most critical waste issues are:

1. Delay before packaging (RPN: 225.00)
2. Distance between draining station and work areas (RPN: 208.13)
3. Delay before drying due to no sunlight (RPN: 200.00)
4. Distance between tray stack and rolling area (RPN: 191.25)
5. Delay before rolling (RPN: 175.00)
6. Drying delay due to rain (RPN: 172.50)
7. Delay before draining (RPN: 150.00)

These seven points are prioritized for improvement to reduce waste and enhance the overall efficiency of the yellow noodle production process.

3.6 Proposing Improvement Solutions

The proposed improvements are based on the most critical types of waste, as identified by the highest RPN values from the FMEA results in Table 3. There are three main improvement proposals selected based on the top-ranked failure modes:

1. Procurement of a Dryer Machine

The drying process in yellow noodle production aims to reduce moisture content to extend shelf life. According to the Indonesian National Standard (SNI) No. 01-2974-1996, dried noodles should have a moisture content of 8–10% (Purnamasari et al., 2019). Currently, SMI relies on traditional sun drying with ambient temperatures ranging between 27–35°C. However, this method is inconsistent due to dependence on weather and time. If the noodles do not dry within three days, mold may form. From the FMEA analysis, the delays due to night-time and rainy weather received high RPN scores of 200 and 172.50, respectively. To address this issue, discussions with the business owner led to the selection of a 40-tray dryer machine as the most suitable solution to ensure consistent and reliable drying.

2, Layout Improvement

From the FMEA results, layout-related waste ranked second and fourth in RPN values:

- Distance between the draining station and rolling areas (RPN: 208.13)
- Distance between tray stacks and rolling area (RPN: 191.25)

These inefficiencies in transportation stem from poor layout utilization and habitual working practices that have not adapted to spatial optimization. To improve this, the Activity Relationship Chart (ARC) method is proposed. ARC is a visual tool used to represent the relationship intensity between production activities or departments, helping to optimize material flow, workstation adjacency, and space use (Amelia et al., 2024).

3. Creation of Worker Arrival Schedule

Delays identified as waiting-type waste ranked first, fifth, and seventh in RPN values:

- Delay before packaging (RPN: 225.00)
- Delay before rolling (RPN: 175.00)
- Delay before draining (RPN: 150.00)

These delays occur due to inefficiencies in current work scheduling, where workers determine their own start times. To mitigate this, a structured worker arrival schedule was created based on current process timings and aligned with prior improvement proposals. The schedule aims to eliminate process delays provided that workers adhere to the arrival times, supported by supervision from the business owner.

3.7 Future Process Activity Mapping (FPAM)

Future Process Activity Mapping (FPAM) is a visual and analytical tool used to represent the ideal future state of activities within a production environment. The purpose of FPAM is to identify which activities can be eliminated, reduced, or modified based on the improvement proposals previously recommended, such as the procurement of a dryer machine, layout improvements, and the creation of a worker arrival schedule. The FPAM reflects expectations for a more efficient workflow by minimizing or eliminating unnecessary activities and enhancing the value-added components of the process.

Table 4. Summary of activity types in FPAM

Activity type	Number of activities	% of activities	Time (sec)	% of time
Value Added (VA)	18	40.91%	35,916.5	91.66%
Non-Value Added (NVA)	0	0.00%	0	0.00%
Necessary Non-Value Added (NNVA)	26	59.09%	3,266.6	8.34%
Total	44	100%	39,183.1	100%

From Table 4, it can be seen that Necessary Non-Value Added (NNVA) activities dominate the total number of activities, accounting for 59.09%, although they consume only 8.34% of the total process time. Value-Added (VA) activities represent 40.91% of total activities but consume the majority of time, accounting for 91.66%. There are no identified Non-Value Added (NVA) activities in the future process map, indicating successful elimination of wasteful steps as a result of the proposed improvements.

Table 5. Summary of activity elements in FPAM

Activity element	Number of activities	% of activities	Time (sec)	% of time
Operation (O)	30	68.18%	37,080.5	94.63%
Transportation (T)	14	31.82%	2,102.6	5.37%
Inspection (I)	0	0.00%	0	0.00%
Storage (S)	0	0.00%	0	0.00%
Delay (D)	0	0.00%	0	0.00%
Total	44	100%	39,183.1	100%

From Table 5, it can be observed that the majority of the process steps are Operational activities, making up 68.18% of the total activities and consuming 94.63% of the total time. Transportation activities account for 31.82% of the activity count and 5.37% of the process time. There are no activities related to inspection, storage, or delay, indicating that inefficiencies related to these categories have been fully addressed or avoided through process redesign.

3.8 Future State Value Stream Mapping (FVSM)

Future Value Stream Mapping (FVSM) represents a visualization of the anticipated ideal process flow that integrates all proposed improvements to reduce waste and enhance process efficiency. It builds upon the current state by illustrating the future condition of production activities after changes such as the procurement of a drying machine, layout optimization, and scheduling improvements have been implemented. The creation of the FVSM refers to the expected elimination or transformation of non-value-added activities and necessary non-value-added steps. Based on the FVSM in Figure 2, the lead time is reduced to 31,983.10 seconds, with a decrease of 97,270.5 seconds, and the PCE value increases to 91.66%, with an increase of 43.34%.

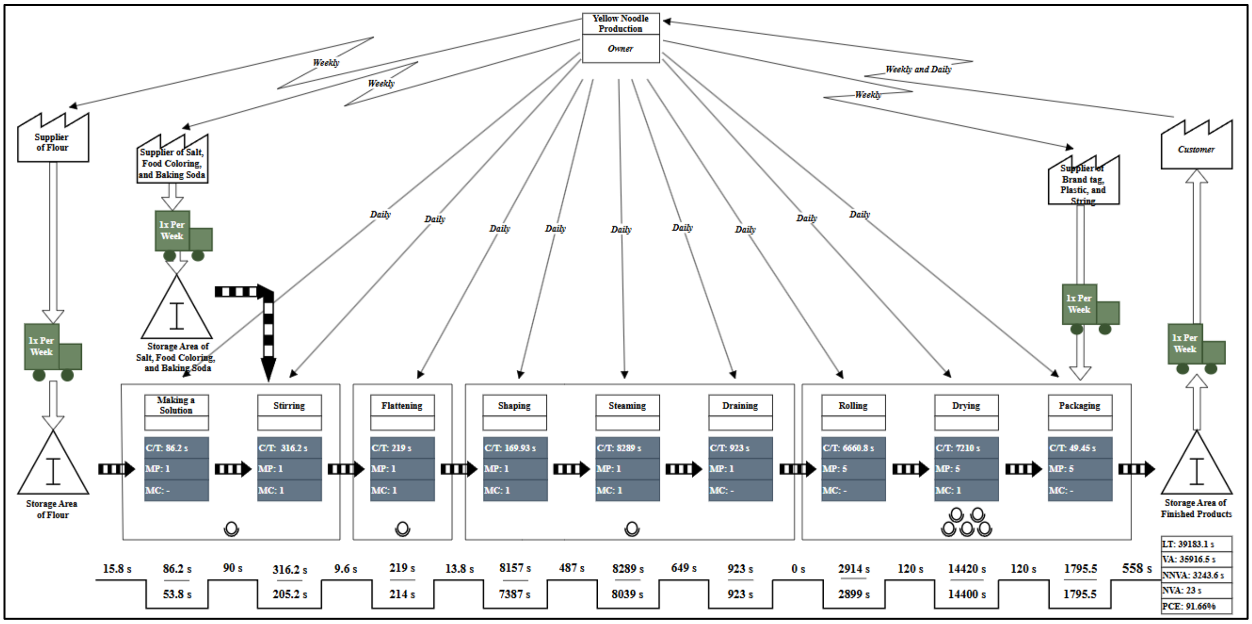

Figure 2. Future Value Stream Mapping

4. Conclusion

This study applied lean manufacturing tools to improve the yellow noodle production process at SMIs in Padang. Through the use of Failure Mode and Effect Analysis (FMEA), the most critical wastes were identified, primarily within the categories of waiting and transportation. The highest Risk Priority Number (RPN) values were associated with delays before packaging, inefficient layout between workstations, and delays in the drying process due to dependence on weather conditions. To address these issues, three key improvement strategies were proposed: the procurement of a dryer machine, layout redesign, and the implementation of a structured worker arrival schedule. These interventions were validated using Future Value Stream Mapping (FVSM), which demonstrated a significant reduction in lead time—from 136,453.6 seconds to 39,183.1 seconds—and an increase in Process Cycle Efficiency (PCE) from 48.32% to 91.66%. The substantial difference in time is primarily due to the elimination of non-value-added activities, especially the long drying time previously dependent on unpredictable weather conditions. The introduction of a mechanical dryer allowed continuous and consistent drying, significantly reducing idle time. Additionally, optimizing the layout minimized transportation delays between workstations, while synchronized worker scheduling prevented bottlenecks at key production stages. These changes collectively contributed to a drastic reduction in total lead time and explain the large numerical difference observed.

These results confirm that the proposed improvements not only reduce waste but also enhance overall production efficiency in a measurable and sustainable manner. Future research could explore the applicability of these lean improvement methods in other food-related SMEs or different industry sectors with similar challenges.

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