



Analysis of Lean Manufacturing Implementation With Value Stream Mapping and Failure Mode And Effect Analysis Method

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Abstract

PT. XYZ is a company that focuses on batik cloth production. This company produces batik cloth manually or what is commonly called *mencanting*. In its production process, PT. XYZ experiences obstacles in the form of waste problems. One effort to reduce or reduce this waste is by identifying the root of the waste that is occurring. Therefore, research was conducted using the lean manufacturing method and the help of value stream mapping to map the entire production process flow to make it easier to identify activities or processes that do not have a good impact. Then failure mode and effect analysis were also used to determine what priorities needed to be handled first so that this waste did not worsen production activities. From the results of the study, waste of the types of Defect, waiting, excess processing, excess inventory, and overproduction were obtained. The proposed improvements that can be given are eliminating unnecessary activities, conducting routine inspections of tools and machines, and creating a routine schedule for maintenance of tools and machines. In addition, it is also necessary to take firm action on the condition of employees, tools, and machines so that they are always maintained and always optimal.

Introduction

The batik industry in Indonesia is one of the sectors that has great potential in supporting national economic growth. The increasingly tight competition in this industry requires batik companies to continue to improve the effectiveness and efficiency of their production processes in order to remain competitive in the market. However, many batik companies, especially those that still use traditional methods such as batik canting or tulis, face challenges in achieving optimal productivity levels (Guptam, 2024; Bello & Olufemi, 2024; Setiawan & Cholili, 2023; Rathakrishnan et al., 2024; Barker, 2020; Sipayung et al., 2022). One of the main problems faced is inefficiency in the production process, which causes increased operational costs, decreased quality, and the inability to meet market demand in a timely manner. In addition, limited technology and poorly trained human resources are also contributing factors to slow production (Setyorini et al., 2013; Andansari et al., 2024; Nugroho, 2013; Raya et al., 2021). Many batik companies have not implemented a good.

PT XYZ is one of the companies engaged in the production of hand-drawn batik or canting. This company always strives to improve its performance to improve the quality of the products produced (Ferdows & De Meyer, 1990; Yeung, 2008). The batik produced is in the form of canting batik which is done manually. In the process of making 1 batik cloth, it takes about 6 days until the cloth becomes a batik cloth with various patterns. However, in the production process, this company faces problems in terms of production time efficiency,

where the batik making process still experiences a lot of waste (Syed Shaharuddin et al., 2021; Sutanto et al., 2024; Handayani et al., 2021). One of the main factors causing this waste is the high waiting time at each stage of production of 1-2 hours, resulting in long lead time losses, as well as an imbalance in the work flow which makes the process ineffective. In addition, the company also experiences quite high product defects of 6% -10%. This defect is in the form of wax shedding (nglorod) and tearing. The coloring and drying process is often delayed due to weather conditions and lack of adequate supporting facilities. This has an impact on increasing production time which is longer than it should be, thus hampering the fulfillment of customer orders. The availability of raw materials which is not always stable also adds to the complexity of production management (Akindipe, 2014; Lee et al., 2018; Diemer et al., 2018; Ku & Hung, 2014). If this problem is not addressed immediately, the company may experience a decrease in profitability and customer trust.

The approaches used in this study are Value Stream Mapping (VSM) and Failure Mode and Effect Analysis (FMEA). According to Braglia et al. (2006) Value Stream Mapping is used to map the entire production process flow, identify waste that occurs, and determine critical points that need to be fixed (Aisyah, 2020; Zaman, 2014). With this method, companies can understand how materials and information flow in the production process and find parts that are experiencing obstacles. Meanwhile, Failure Mode and Effect Analysis is used to analyze potential failures in the production process and develop mitigation strategies to reduce the level of product defects. Failure Mode and Effect Analysis helps companies identify risks at each stage of production and evaluate the impact of each potential failure (Liu et al., 2013; Carlson, 2012; Segismundo & Augusto Cauchick Miguel, 2008).

Literature

Lean Manufacturing

Lean is a tool used to help reduce product waste, costs, time and so on. Lean is a way to minimize waste and to increase the added value of a product to customers through continuous improvement. (Darmawan et al., 2023) Lean Manufacturing is a concept of a systemic and systematic approach to finding and identifying waste that exists and occurs during the production process by eliminating (non-value adding activities) or activities that do not add value through continuous improvement by flowing products properly (materials, work in process, output) and using a customer pull system so that the manufacturing industry is superior and creates perfection (Tarantino, 2022; Kumar et al., 2022; Dupin, 2021).

Value Stream Mapping (VSM)

According to Aisyah, (2020) Value Stream Mapping (VSM) is one of the most important tools in implementing lean manufacturing, which is used to map the flow of materials and information that occurs in a production process, from the supply of raw materials to finished products ready to be sent to customers. The value stream itself refers to the entire series of activities that create value for customers, from receiving raw materials, production, to shipping the final product. VSM helps to visually describe and analyze the process, with the aim of identifying and eliminating waste in the production system. This mapping allows the management team to clearly see the value flow that occurs at each stage of the process, as well as identify critical points that need improvement (Wang et al., 2022; Florescu & Barabas, 2022).

Fishbone Diagram

According to Carlson (2015) Fishbone Diagram, or often known as Ishikawa Diagram or Cause and Effect Diagram, is a tool used to analyze and describe the causes of a problem or effect that occurs in a process. This diagram was first developed by Kaoru Ishikawa, a Japanese quality expert, in the 1960s, as part of an effort to improve product quality in the

manufacturing industry. According to Sakdiyah et al. (2022) Fishbone Diagram is a visual tool used to identify, map, and analyze various causes that may affect a problem or effect in a process. This diagram helps to dig into the root cause of the problem that occurs, so that the team can take appropriate action to fix it

Big Picture Mapping (BPM)

According to Braglia et al. (2021) Failure modes with high RPN (e.g., more than 100) will be the top priority to be addressed. In other words, the higher the RPN, the more important it is to identify the cause of the failure and take corrective action to reduce the risk. Big Picture Mapping (BPM) is one of the tools used in Lean Manufacturing to map and describe the overall process flow in an organization or system (Rahani & Al-Ashraf, 2012).

Failure Mode and Effect Analysis (FMEA)

According to Dissanayake (2022) Failure Mode and Effect Analysis (FMEA) is a systematic method used to identify and analyze potential failure modes in a system, product, or process, and the impacts they cause. FMEA aims to assess the risk of failure and assist in decision making to prevent or reduce the likelihood of failure that can adversely affect the quality, safety, and performance of a product or process. FMEA is used to provide a clear picture of potential failures, their causes, and impacts, and to prioritize corrective or risk mitigation actions (Idham, 2010).

Methods

Data Collection Methods

The data collection stage is carried out by direct observation and interviews. The data collected are primary data and secondary data.

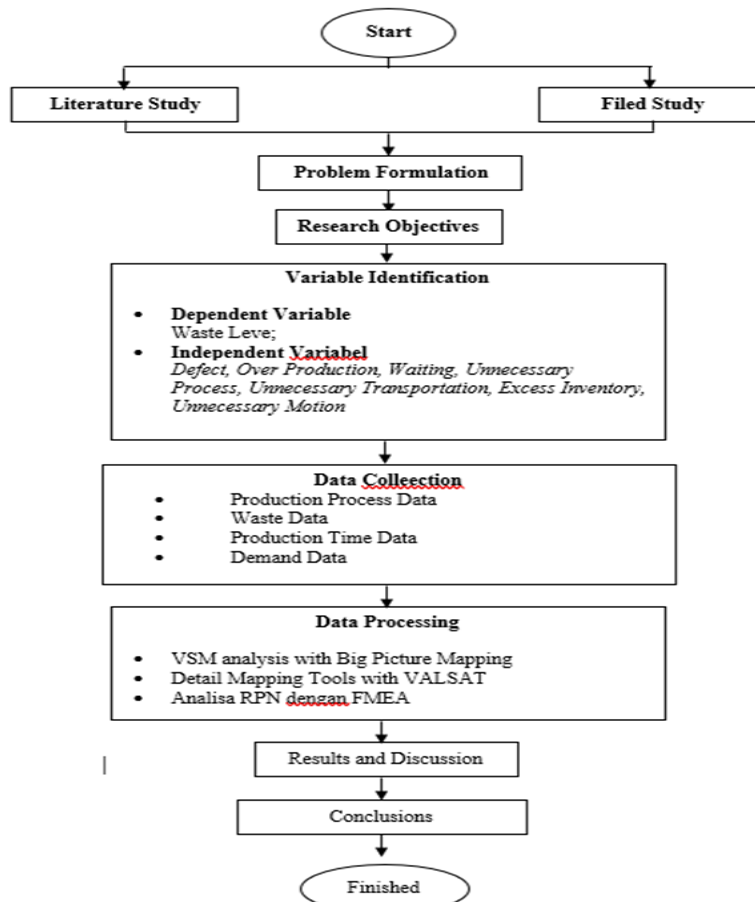


Figure 1. Data Processing Method

Literature Study

Literature study is a stage of searching for references from books, journals or previous research that are directly related or interfere with the research conducted, namely about lean manufacturing, value stream mapping, Big Picture Mapping, and Failure Mode and Effect Analysis. In order to provide knowledge and references to help identify problems and support the methods used.

Field Study

Waste data from observations and interviews with PT. Trijaya Berlah Mulia with the aim of finding out how much waste occurs in the company. The data are production process data, waste data, and production time data.

Results and Discussion

To identify the level of waste in the production process of Batik Tulis at PT. XYZ, a study was conducted by observing and interviewing employees and company managers to reduce waste including Defect, Waiting, Excess Overproduction, Unnecessary Transportation, Excess Inventory, Unnecessary Motion, and Unnecessary Process. The collected data will later be processed using Value Stream Mapping (VSM) and Failure Mode and Effect Analysis (FMEA) tools to provide suggestions for improvement.

Data Collection

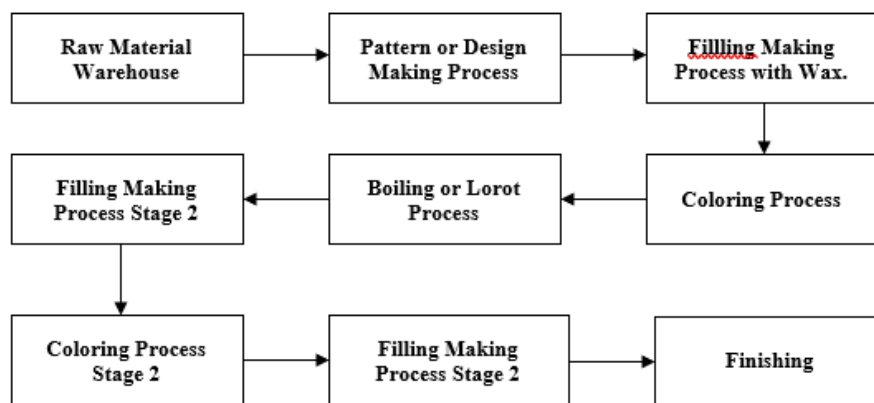


Figure 2. Production Flow Data

Tabel 1. Defect Data

Period (2024)	Production Quantity	Defect Quantity	Defect Percentage
January	400	27	6,75%
February	400	25	6,25%
March	440	43	9,77%
April	380	29	7,63%
May	360	23	6,38%
June	400	31	7,75%
July	380	26	6,84%
August	440	41	9,31%
September	380	28	7,36%
Oktober	360	30	8,3%
November	340	24	7,05%
December	380	33	8,63%
Total	4660	360	92,02%
Average	388,33	30	7,67%

Tabel 2. Waiting Time Data

Process Activity	Waiting (minutes)
Waiting for wax heating stage 1	15
Waiting for the temperature to warm up in the stage 2 boil and saute tool	30
Wait for the cloth to cool stage 1	10
Waiting for wax heating stage 2	15
Waiting for the temperature to warm up in the stage 2 boil and saute tool	30
Wait for the cloth to cool stage 2	10

Tabel 3. Excess Production Data

Period (2024)	Demand Quantity (Pcs)	Production (Pcs)	Excess Procution Quantity (pcs)
January	384	400	16
February	396	400	24
March	432	440	8
April	372	380	8
May	348	360	12
June	380	400	20
July	372	380	8
August	420	440	20
September	360	380	20
Oktober	348	360	12
November	336	340	4
December	372	380	8
Total	4520	4660	140
Average	376,66	388,33	11,66

Tabel 4. Warehouse Storage Data

Period (2024)	Inventory Storage Standard 400 pcs	
	Production (pcs)	Excess Inventory Beyond Warehouse Capacity
January	400	16
February	400	24
March	440	8
April	380	8
May	360	12
June	400	20
July	380	8
August	440	20
September	380	20
Oktober	360	12
November	340	4
December	380	8
Total	4660	140
Average	388,33	11,66

Tabel 5. Unnecessary Process Data

Unnecessary Process			
Period (2024)	Type of Issue	rework (pcs)	Rework Rate (%)
January	<i>Rework</i>	27	6,75%

February		25	6,25%
March		43	9,77%
April		29	7,63%
May		23	6,38%
June		31	7,75%
July		26	6,84%
August		41	9,31%
September		28	7,36%
Oktober		30	8,3%
November		24	7,05%
December		33	8,63%
Total		360	92,02%
Average		30	7,67%

Tabel 6. Data Information on Batik Cloth Production Time Per Day

No	Aktivitas	Time (Mnts)	Activity
RAW MATERIAL WAREHOUSE			
1	Inspection of raw fabric	20	Inspection
2	Transportation of raw fabric to pattern and motif station	10	Transportation
PATTERNING AND MODIFING			
3	Set up cutting tools	5	Operation
4	Cutting process	30	Operation
5	Placement of fabric onto motif and pattern tools	15	Operation
6	Set up motif and pattern equipment	10	Operation
7	Patterning and motifing process	240	Operation
BATIK WAXING AND FILLING STAGE 1			
8	Transporting patterned fabric	15	Transportation
9	Set up waxing and filling tools	30	Operation
10	Waiting for wax heating	15	Delay
11	Batik waxing and filling process	360	Operation
12	Inspection of wax result on fabric	30	Inspection
DYEING STAGE 1			
3	Transporting batik fabric	15	Transportation
14	Set up dyeing equipment	30	Operation
15	Fabric dyeing process	180	Operation
16	Drying process	120	Operation
17	Transporting dried fabric	30	Transportation
BOILING AND WAX REMOVAL STAGE 1			
18	Set up boiling and wax removal equipment	15	Operation
19	Waiting for temperature heating	30	Delay
20	Boiling and wax removal process	60	Operation
21	Transporting boiled fabric	30	Operation
22	Waiting for fabric to cool	10	Delay
23	Set up washing equipment	5	Operation
24	Washing process	30	Operation
25	Transporting washed fabric	10	Operation
26	Drying process	120	Operation
27	Transporting dried fabric	30	Transportation

BATIK WAXING AND FILLING STAGE 2			
28	Set up waxing and filling tools	30	Operation
29	Waiting for wax heating	15	Delay
30	Batik waxing and filling process	360	Operation
31	Inspection of wax result on fabric	30	Inspection
DYEING STAGE 2			
32	Transporting batik fabric	15	Transportation
33	Set up dyeing equipment	30	Operation
34	Fabric dyeing process	180	Operation
35	Drying process	120	Operation
36	Transporting dried fabric	30	Transportation
BOILING AND WAX REMOVAL STAGE 2			
37	Set up boiling and wax removal equipment	15	Operation
38	Waiting for temperature heating	30	Delay
39	Boiling and wax removal process	60	Operation
40	Transporting boiled fabric	30	Operation
41	Waiting for fabric to cool	10	Delay
42	Set up washing equipment	5	Operation
43	Washing process	30	Operation
44	Transporting washed fabric	10	Transportation
45	Drying process	120	Operation
46	Transporting dried fabric	30	Transportation
FINISHING			
47	Quality inspection	30	Inspection
48	Fabric packaging	15	Operation
49	Transporting fabric to finished goods warehouse	20	Transportation
FINISHED GOODS WAREHOUSE			
50	Storage and arrangement of fabric	10	Storage

Big Picture Mapping

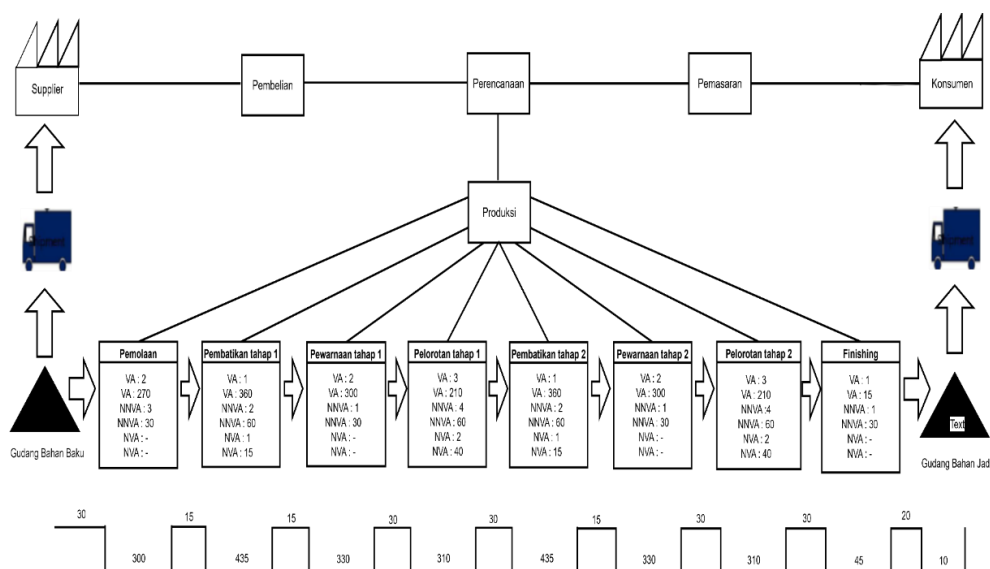


Figure 3. Big Picture Mapping

The calculation of the Big Picture Mapping above is:

Total Production Time (Lead Time)

= 2720 Minutes = 45 hours 20 minutes

The total production time or lead time for batik cloth production is 2720 minutes, if converted into hours it is 45 hours 20 minutes and the value added time is 2025 minutes or 33 hours 45 minutes..

Tabel 7. Presentase Frequency and Time of Activity Type

No	Activity	Frequency	Presentation	Time (Minutes)	Presentation
1	<i>Operation</i>	29	58%	2285	84,2%
2	<i>Transportation</i>	10	20%	205	7,5%
3	<i>Inspection</i>	4	8%	110	4%
4	<i>Storage</i>	1	2%	10	0,3%
5	<i>Delay</i>	6	12%	110	4%
Total		50	100%	2710	100%

After knowing the number of activities and time required for each batik cloth production activity, the various activities will be grouped according to the type of activity. There are 3 types of activities, namely value added activity, non value activity and necessary but non value added activity. The results of the grouping of these activities are:

Tabel 8. Percentage Frequency and Time of Activity Type

No	Activity	Frequency	Presentation	Time (Mnts)	Perentg
1	Value Added Activity	15	30%	2025	74,5%
2	Non Value Activity	6	12%	110	4%
3	Necessary but Non Value Activity	29	58%	585	21,5%
Total		50	100%	2720	100%

VALSAT Mapping Tools Detail

Calculation of Percentage Frequency of Each Activity

Operation

$$\frac{29}{50} \times 100\% = 58\%$$

Transportation

$$\frac{10}{50} \times 100\% = 20\%$$

Inspection

$$\frac{4}{50} \times 100\% = 8\%$$

Storage

$$\frac{1}{50} \times 100\% = 2\%$$

Delay

$$\frac{6}{50} \times 100\% = 12\%$$

Percentage Time Calculation for Each Activity

Operation

$$\frac{2285}{2720} \times 100\% = 84.2\%$$

Transportation

$$\frac{205}{2720} \times 100\% = 7.5\%$$

Inspection

$$\frac{110}{2720} \times 100\% = 4\%$$

Storage

$$\frac{10}{2720} \times 100\% = 0.3\%$$

Delay

$$\frac{110}{2720} \times 100\% = 4\%$$

Table 9. Percentage of Frequency and Time of Each Activity

No	Activity	Frequency	Presentation	Time (Minutes)	Presentation
1	Value Added Activity	15	30%	2025	74,5%
2	Non Value Added Activity	6	12%	110	4%
3	Necessary but Non Value Added Activity	29	58%	585	21,5%
Total		50	100%	2720	100%

Value added activities are activities that add value to a product in the eyes of customers. Non value added activities are activities that do not add value to a product and should be eliminated because they only waste time, money, or energy. Necessary but non value added activities are activities that do not add value directly, but are still needed under certain conditions.

Activity Type Frequency Calculation

$$\text{Value Added Activity} : \frac{15}{50} \times 100\% = 30\%$$

$$\text{Non Value Added Activity} : \frac{6}{50} \times 100\% = 12\%$$

$$\text{Necessary but Non Value Added Activity} : \frac{29}{50} \times 100\% = 58\%$$

Activity Type Time Calculation

$$\text{Value Added Activity} : \frac{2025}{2720} \times 100\% = 74.5\%$$

$$\text{Non Value Added Activity} : \frac{110}{2720} \times 100\% = 4\%$$

$$\text{Necessary but Non Value Added Activity} : \frac{585}{2720} \times 100\% = 21.5\%$$

Table 10. Percentage of Frequency and Time of Activity Type

Per	Activity	Freq	Prctng	Time (Mnts)	Prctng
1	Value Added Activity	15	35%	2025	77,53%
2	Non Value Added Activity	0	0%	0	0%
3	Necessary but Non Value Added Activity	29	65%	585	22,47%
Total		44	100%	2610	100%

Risk Priority Number Analysis with FMEA

After knowing the root of the problem that occurs in the batik cloth production activity, the next step is to analyze it using FMEA. FMEA here is useful for knowing the priority of improvements made. There are 3 main variables in FMA, namely severity, occurrence, and detection. The value or rating of the 3 variables is obtained from interviews and brainstorming with the owner and head of production at PT. XYZ.

Table 11. Risk Priority Number Calculation

Waste Type	Type of Defect	Cause of Defect	Effect of Defect	Severity	Occurance	Detection	RPN
Defect	Torn fabric, wax detachment, missing motifs, and incorrect coloring on batik fabric	Equipment and machinery not functioning optimally, improper SOP implementation, variation in material strength	Imperfect wax melting and substandard dye or boiling water cause product defects	7	8	7	392
Waiting	Waiting for equipment/machi	Due to waiting for wax heating (stage	Increased production	8	7	6	336

	ne heating and fabric readiness	1 & 2), equipment temperature heating (stage 1 & 2), and fabric cooling (stage 1 & 2)	time and lead time				
Excess Process	Presence of excessive production process due to defective products	High quantity of defective products	Increased production time and lead time	6	7	5	210
Waste Type	Type of Defect	Cause of Defect	Effect of Defect	Seve	Occu	Defe	RPN
Excess Inventory	Presence of raw materials or finished goods that cannot be stored or are piling up in the warehouse	Overproduction of goods	Excessive inventory needs to be stored and there is a risk that the warehouse may not have enough space to accommodate it	6	4	5	120
Overproduction	Surplus products produced beyond customer demand	Miscalculation in production planning and inconsistencies in proposed production targets	High volume of unsold products, increased storage needs, rising production costs, and unnecessary processes	5	4	4	80

Recimmendations for Improvement

After processing the data related to all that is obtained from the Company, recommendations are given to determine the waste that must first be repaired or prioritized. Handling this waste refers to the *Risk Priority Number* (RPN) value which is sorted based on the value or level results. The proposed improvements given are as follows:

Table 12. Proposed Improvements

Waste	Subwaste	RPN	Level	Improvement
Defect	Equipment and machines not functioning optimally, SOP not followed properly,	392	Very High	Conduct routine inspections of equipment and machines as well as fabric used; consistently follow proper SOPs.

	and variations in material strength			
Waiting	Downtime and lead time issues	336	Very High	Perform machine setups while fabric is still being processed at one or two previous stations to eliminate delays.
Excess Process	High number of defective products requiring rework	210	High	Reduce the production of defective products by minimizing errors and optimizing processes at each workstation.
Excess Inventory	Overproduction	120	High	Finalize all finished goods stored in the warehouse and optimize warehouse capacity by monitoring inventory levels.
Overproduction	Planning errors and conflicting proposals	80	Low	Improve coordination among related departments and align production quantity with actual customer demand.

Tabel 13. Production Time Adjustment

No	Process	Time Before Improvement (Minutes)	Time After Improvement (Minutes)
1	Waiting for wax heating (Stage 1)	15	0
2	Waiting for temperature heating in boiling and wax removal equipment (Stage 1)	30	0
3	Waiting for fabric to cool (Stage 1)	10	0
4	Waiting for wax heating (Stage 2)	15	0
5	Waiting for temperature heating in boiling and wax removal equipment (Stage 2)	30	0
6	Waiting for fabric to cool (Stage 2)	10	0

Big Picture Mapping Update

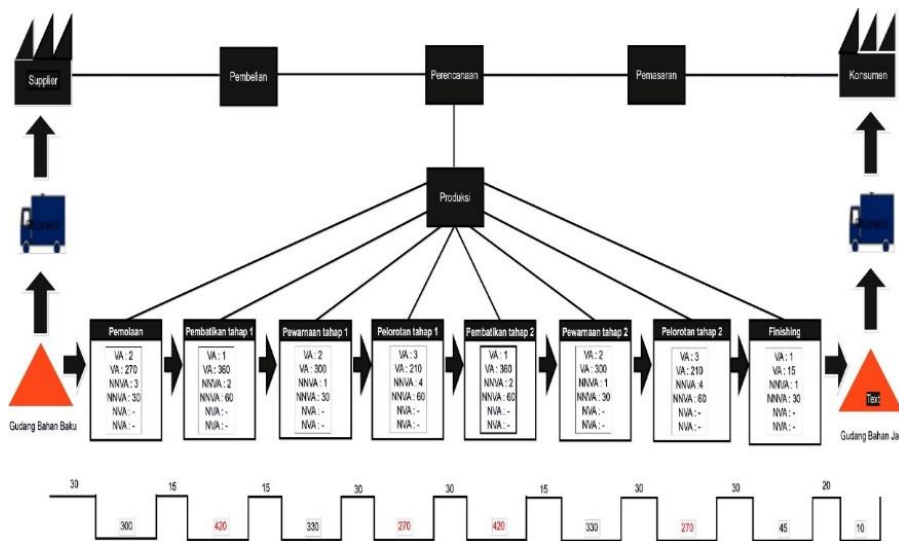


Figure 4. Big Picture Mapping

Time calculation after repair:

Total Value Added	= 2025 Minutes
Total Non Value Added	= 0 Minutes
Total Necessary but Non Value Added	= 585 Minutes
Total Production Time	= 2610 Minutes

Table 14. Calculation of Total Time Before and After Repair

Time Before Improvement	Time After Improvement
2720 Minutes	2610 Minutes
45 Hours 20 Minutes	43 Hours 30 Minute

Table 15. Calculation of Repair Production Process

No	Activity	Frequency	Prcntg	Time (Mnts)	Prcntg
1	Value Added Activity	15	30%	2025	74,5%
2	Non Value Added Activity	6	12%	110	4%
3	Necessary but Non Value Added Activity	29	58%	585	21,5%
Total		50	100%	2720	100%

The analysis of waste in the batik production process at PT XYZ reveals a consistent pattern of inefficiencies that hinder operational performance. By employing the Value Stream Mapping and Failure Mode and Effect Analysis frameworks, the study uncovers five major sources of waste that significantly reduce production effectiveness. These include defects, waiting time, excess processing, excess inventory, and overproduction. Each of these elements contributes differently to the broader issue of production delays, cost inefficiencies, and reduced product quality, making it essential to examine their implications in greater detail.

Among all the identified types of waste, defects emerge as the most urgent concern. The average rate of product defects reaches nearly eight percent over the observed year. These defects stem primarily from technical and procedural inconsistencies, including malfunctioning tools, the inconsistent application of standard operating procedures, and irregularities in material strength. The defects manifest as torn fabrics, incomplete patterns, or color inaccuracies, which not only compromise product quality but also trigger a chain reaction of rework and resource loss. The high risk score associated with this waste category reflects the critical urgency of addressing it through regular equipment inspection, strict procedural enforcement, and raw material standardization. Waiting time also constitutes a significant problem, particularly in stages involving fabric cooling and wax heating. The cumulative delays from these processes add over one hundred minutes to the total production time, reflecting a substantial loss in efficiency. These idle moments are not merely isolated incidents but are embedded within the production rhythm, causing a slowdown in the overall workflow. Reducing these waiting times by synchronizing equipment preparation with prior steps in the production cycle would allow for more seamless transitions between activities and a more continuous flow of work.

Another persistent issue involves excess processing, which largely arises from the need to redo faulty outputs. This problem indicates a deeper structural inefficiency where defects not only affect product quality but also elongate production cycles. When rework becomes a regular feature of the production environment, it absorbs both time and labor that could otherwise be allocated to more productive tasks. Therefore, resolving the root causes of defects will likely diminish the need for unnecessary repetition and contribute to a more streamlined process.

The presence of excess inventory reflects a misalignment between production output and warehouse capacity. Although this issue does not exhibit the same level of urgency as defects or waiting time, it still poses a risk to space utilization and cost control. Inventory overflow often results from overproduction or inaccurate demand forecasting. Addressing this issue requires closer coordination among departments, better planning tools, and a more dynamic approach to tracking real-time demand and production rates. Overproduction, while carrying the lowest priority in terms of immediate risk, still represents a silent contributor to systemic inefficiency. Producing more goods than necessary not only strains storage capacity but also increases the likelihood of spoilage, obsolescence, or unfulfilled sales. Even though its impact is less visible in the short term, its financial and logistical consequences accumulate over time. Aligning production levels more closely with actual market demand would help prevent the buildup of unnecessary inventory and reduce hidden costs.

Following the proposed improvements, the total production time shows a measurable reduction. By eliminating non-value activities, especially those related to waiting, the company is able to decrease the lead time from forty-five hours to just over forty-three hours. This improvement is not only a numerical success but also an operational one, as it indicates a shift toward leaner and more responsive manufacturing. The distribution of time spent on value-added tasks increases accordingly, showing a meaningful change in how resources are allocated. While value-added activities now occupy a larger proportion of the production process, necessary but non-value activities still remain significant. These are tasks that do not directly add value from the customer's point of view but are still essential given the current structure of the production system. Future process improvements should explore whether these intermediate tasks can be automated, integrated, or even eliminated without compromising output quality. A deeper investigation into these components may offer additional opportunities for improvement and long-term sustainability.

Conclusion

The findings of this study confirm that the production process at PT XYZ is significantly constrained by five primary types of waste, namely defects, waiting time, excess processing, excess inventory, and overproduction. Among these, defects and waiting time emerge as the most critical, both contributing heavily to extended lead times and inefficiencies across the production flow. The presence of these wastes reflects structural issues in both operational execution and planning accuracy, where misalignments in equipment readiness, standard operating procedure adherence, and production forecasting disrupt the rhythm of value creation. The application of Value Stream Mapping and Failure Mode and Effect Analysis has proven effective in not only identifying these inefficiencies but also prioritizing them based on risk and impact, allowing for targeted improvements that directly reduce production time and eliminate non-value activities. The subsequent reduction in lead time and the increase in value-added activities suggest a promising shift toward a leaner and more responsive manufacturing system. Although some necessary but non-value activities remain, their identification lays the groundwork for future innovations that can further streamline operations. This study demonstrates that with structured analysis and actionable recommendations, traditional batik production can evolve into a more efficient, cost-effective, and competitive enterprise while preserving its cultural integrity.

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