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Research Article

A Solution Approach on Reducing Defects in Batik Tanah Liek Production Process of a Small and Medium-sized Enterprise

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ABSTRACT

Small and medium enterprises (SMEs) often struggle with implementing effective quality management practices, especially in traditional industries like batik production. These challenges include ensuring consistent product quality to differentiate from competitors and attract customers. This study focuses on addressing quality control issues in small-scale Batik Tanah Liek production, where significant defects persist. The research aims to assess existing practices, identify defect causes, and propose solutions to enhance product quality and reduce rejection rates. These efforts contribute to improving production efficiency and supporting the sustainability of this traditional craft. The study employs a systematic approach combining quality management methodologies, including data collection, problem identification, brainstorming, the Failure Mode and Effects Analysis (FMEA) approach, and actionable recommendations. Data was gathered through a questionnaire to capture perspectives on defects and quality control issues in batik production. Key quality challenges identified include faded batik, torn fabric, and incorrect motifs. Analysis revealed that the primary cause of incorrect motifs is the malfunctioning canting tool, which hinders proper wax application. Additionally, defects in dyeing and boiling processes contribute to fabric fading and tearing, exacerbating quality issues. The findings underscore the need for systematic solutions, such as creating clear work instructions, designing Standard Operating Procedures (SOPs) for process consistency, and implementing preventive maintenance schedules for equipment. By addressing these issues, the study provides practical interventions to improve production quality. These measures not only enhance the economic viability of SMEs but also play a crucial role in preserving the cultural heritage of Batik Tanah Liek. The implications of this research highlight the potential for broader adoption of quality management practices in traditional industries to ensure their sustainability in competitive markets.

Keywords: Quality management, defect reduction, batik tanah liat, FMEA, SME

INTRODUCTION

Small and Medium Enterprises (SMEs) are vital contributors to economic development, accounting for significant portions of employment and GDP worldwide. Despite their importance, SMEs often face challenges in implementing robust quality management systems due to resource constraints and operational limitations. Research highlights that adopting Total Quality Management (TQM) principles can enhance SMEs' operational efficiency and financial performance, even under challenging conditions such as economic crises [1]. However, many SMEs still lack structured quality management frameworks, limiting their ability to compete in increasingly globalized markets [2]. Modern quality methodologies, such as Lean and Six Sigma, have proven effective in helping SMEs improve process reliability and reduce defects, enabling them to remain competitive [3].

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Within this broader context of quality management in SMEs, traditional industries like batik production serve as a unique case study. Batik is a renowned Indonesian craft celebrated for its intricate designs and cultural significance. Produced using a wax-resist dyeing technique, batik showcases vibrant and detailed patterns that reflect the cultural identity and history of its creators. Recognized by UNESCO as a Masterpiece of Oral and Intangible Heritage of Humanity, batik is more than an art form; it is a livelihood for artisans and a symbol of national pride. Its production contributes not only to cultural preservation but also to economic development, particularly in rural areas.

Among the diverse styles of batik, Batik Tanah Liek, originating from West Sumatra, stands out for its use of natural clay dyes, which create earthy tones and patterns deeply tied to Minangkabau traditions [4]. This batik uses clay as a natural dye beside rambutan, jengkol (dog fruit), or gambier plants. The cloth is first soaked for a week with clay and then painted with other natural dyes after being washed. Rubber tree and palm flower batik motifs are consumer favorites, among other motifs. Other unique Minangkabau traditional motifs is sirih dalam carano (betel leaf in carano), kaluak paku (fern leaves), kucing tidur (sleeping cats), lokan (river shells), batuang kayu, tari piriang (plates dance), kipas (folding hand fan), and rangkiang (rice barn in Minangkabau). However, some motifs continue to be developed whose inspiration is drawn from the richness of Minangkabau natural cultures, such as tabuik (ark), jam gadang (clock building in Bukit Tinggi), and rumah gadang (traditional house of the Minang Kabau) motifs [5], [6].

Despite its cultural and economic significance, the sustainability of Batik Tanah Liek faces significant challenges related to inconsistent product quality and inefficient production methods [7]. These challenges undermine its competitiveness in both local and global markets. Defects such as faded patterns, torn fabrics, and incorrect motifs not only compromise the economic viability of producers but also threaten the preservation of cultural heritage [8]. Furthermore, high rejection rates, often caused by tool malfunctions and inefficient production processes, exacerbate financial losses and erode consumer trust [9]. Addressing these persistent issues is critical, particularly for SMEs and family-run businesses that must navigate limited resources and production constraints. The implementation of effective quality management practices is, therefore, essential.

The scale of these challenges is evident in historical production data from January to December 2021, collected from a Batik Tanah Liek SME in Dharmasraya Regency, West Sumatra, Indonesia. This data reveals substantial inefficiencies, with monthly production ranging from 300 to 530 pieces of batik cloth and rejection rates between 4.5% and 11.7%. These rates equate to 21 to 37 rejected pieces per month, resulting in significant financial losses of IDR 5,250,000 to IDR 9,250,000 monthly. The most common defects included faded fabric during the basic coloring, boiling, and washing stages, torn fabric during washing, and incorrect patterns during the pattern-making and mencanting processes. While additional causes of defects exist, their occurrence remains minimal. These findings underscore the urgency of prioritizing quality management and improving production efficiency to secure the sustainability and cultural legacy of Batik Tanah Liek.

Exacerbating these issues is the disparity in quality control practices between small-scale artisanal workshops and larger production facilities. Larger producers often possess the resources to implement advanced quality control measures, whereas smaller producers, like Batik Tanah Liek companies, frequently rely on traditional methods that may lack precision and consistency. This contrast emphasizes a critical research gap: the need to develop quality control practices tailored specifically to small-scale batik producers. Integrating modern quality management techniques with traditional methods offers a promising avenue to address production defects effectively while preserving the unique craftsmanship of Batik Tanah Liek. Such measures would enhance its competitiveness in both local and global markets.

Addressing these defects and bridging the quality control gap is crucial for maintaining product standards and improving overall production processes. Quality management in batik production serves as the cornerstone for ensuring that final products meet the required aesthetics, durability, and performance standards. By implementing

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tailored quality management approaches that respect traditional methods, batik producers can elevate their offerings and sustain a strong market presence. Key measures, including quality planning, process control, training, and leveraging customer feedback, are essential for these efforts. Furthermore, a commitment to continuous improvement and adherence to quality standards is vital for ensuring long-term success and customer satisfaction, enabling Batik Tanah Liek to thrive in an increasingly competitive market.

Quality management practices have been widely recognized as critical for enhancing the competitiveness and sustainability of Small and Medium Enterprises (SMEs). Traditional approaches such as Total Quality Management (TQM), Lean, and Six Sigma have been tailored to address the needs of SMEs. Research highlights that these methodologies foster continuous improvement, enhance operational efficiency, and reduce defects in production processes [3]. In particular, TQM has been shown to boost financial performance by integrating customer focus, continuous improvement, and employee involvement into organizational practices [1]. Similarly, Zero Defect Manufacturing (ZDM) has emerged as a promising approach, emphasizing error prevention and sustainability, particularly in industries requiring precision and consistency [10].

Findings from past studies suggest that integrating quality management practices with artisan-specific techniques can potentially enhance product quality [11], [12]. This approach is particularly relevant to Batik Tanah Liek production, where defects and inconsistencies hinder efficiency and competitiveness. Implementing quality management practices standardizes production processes, ensuring consistent quality and reducing variability [13]. For example, documenting and standardizing key steps—such as dye preparation, wax application, and drying—can help maintain high standards while minimizing errors. In addition to process standardization, advanced methodologies such as Statistical Process Control (SPC) and Six Sigma can play a vital role in improving production efficiency and reducing defects [14]. These techniques enable manufacturers to monitor processes, identify potential issues, and implement targeted improvements. Furthermore, providing artisans with focused training enhances their skills and ensures adherence to quality standards [15]. Continuous improvement, driven by customer feedback, aligns products with market expectations and reinforces long-term customer satisfaction [16].

The combination of formal quality management practices—including SPC, Six Sigma, Total Quality Management (TQM), and Failure Mode and Effects Analysis (FMEA)—with targeted employee training has been shown to improve product quality, reduce defects, and increase operational efficiency. Researchers in the field have highlighted various approaches to implementing quality management, such as Lean Manufacturing, Seven Tools of Quality, Pareto Analysis, or combinations of these methods. Each methodology offers unique advantages and can be adapted to fit the specific needs of Batik Tanah Liek production or other small-scale artisanal industries. Table 1 summarizes methodologies from recent studies that effectively address production defects, providing valuable insights into quality management practices applicable to Batik Tanah Liek production.

Despite these advancements, the focus on systematic quality management solutions specifically tailored to traditional SMEs remains limited. Many SMEs lack the resources and expertise needed to implement advanced methodologies. Moreover, traditional SMEs, particularly in artisanal industries such as batik production, face unique challenges that are not adequately addressed by generic quality management systems. For instance, in the case of Batik Tanah Liek, defects such as faded patterns, torn fabrics, and incorrect motifs persist due to malfunctioning tools and inconsistent dyeing processes. These issues often stem from a lack of preventive maintenance schedules and the absence of standardized operating procedures [8]. Furthermore, while digitalization and artificial intelligence offer potential solutions, their application remains underexplored in resource-constrained traditional SMEs [32].

Specific interventions addressing the unique production challenges of traditional industries are scarce. Many studies emphasize the importance of integrating employee involvement and training into quality management, yet they

Table 1. Methodologies to reduce defects during production

No	Methods or approaches	Cases	References
1	Statistical Process Control Approach	Plastic injection molding Vehicle spare part production	Rohani and Chan [17] Sousa *et al.* [18]
2	Lean Six Sigma methodology	Automobile filters manufacturing Ship assembly and fabrication	Guleria *et al.* [19] Priyanda and Sutanto [20]
3	Total Quality Management (TQM) approach	Electrical parts manufacturing	Sreedharan *et al.* [21]
4	Lean Manufacturing	Rubber production Ceramic industry	Amrina *et al.* [22] Bhamu *et al.* [23]
5	Seven Tools of Quality Method	Food field Company Aircraft and aerospace products	Sanny and Amalia [24] Ginting and Fattah [25]
6	Failure Mode and Effect Analysis (FMEA) approach	Application of FMEA in Polish manufacturing companies Aluminum forgings company	Dudek-Burlikowska [26] Zasadzień [27]
7	Pareto Analysis	Ring spinning in the textile industry, Bangladesh	Hossen *et al.* [28]
8	Root Cause Analysis (RCA)	Galvanized steel sheets company	Xinyan *et al.* [29]
9	Lean, DMAIC (Six Sigma) and FMEA (mixed approach)	Disk brake grinding	Hidayat *et al.* [30]
10	Lean Manufacturing, SPC, and HACCP (mixed approach)	Food company	Cabrera *et al.* [31]

overlook the need for low-cost, pragmatic solutions that cater to SMEs with limited budgets [7]. Moreover, limited emphasis has been placed on addressing specific inefficiencies such as inconsistent wax application in batik production, which is a common cause of defects. While systematic quality management practices offer immense potential for improving SME competitiveness, their adaptation to the unique needs of traditional industries remains inadequate. To address these gaps, future research should focus on developing cost-effective, context-specific interventions that cater to the operational realities of traditional SMEs. By doing so, these industries can enhance product quality, ensure economic viability, and preserve their cultural heritage.

Based on the description above, it can be concluded that it is essential to carry out quality management in the batik production process. Quality control is a management evaluation tool to ensure deviations do not occur, which could later be detrimental to the company [33] [34]. Failure analysis and identification are expected to help the SME minimize defective products and improve quality according to company specifications. An integrated approach will identify each stage of the production process, then assess the technical standards that have been established by the company and find the root causes of the dominant defect problems. As an artistic use/textile item, if there are errors in the production process, making batik products cannot be reworked or become scrap will significantly affect product specifications and reduce consumer trust. Thus, a defect in batik cloth can reduce consumers' purchasing power toward Batik Tanah Liek. This gap must be overcome immediately by providing an appropriate integrated solution approach to minimize defects in the batik production process so that companies can win consumer trust.

This research will address modern quality control methods and approaches to reduce defects in batik production in SMEs that still use traditional practices characterized by craftsmanship, skill, and a high degree of manual involvement. This research is expected to build a framework for integrating traditional and modern practices in various artisanal products (such as Batik Tanah Liek) with modern manufacturing contexts. The first research stage focuses on identifying and understanding the specific aspects of a Batik Tanah Liek production that are important to meeting customer needs and expectations. Then, the research will identify and prioritize problems based on their

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frequency or impact. The study will further analyze the root cause and organize brainstorming to identify all possible causes. A structured approach evaluates and prioritizes potential failure modes within the batik production processes. The objective is to develop and implement improvement actions to address high-priority failure modes.

The proposed research is expected to provide unique contributions by integrating traditional batik techniques with modern quality control methods, offering a holistic approach to quality improvement, and creating a practical framework for enhancing batik production. These contributions advance the batik production field and provide valuable insights for other industries seeking to blend traditional craftsmanship with modern practices.

METHODS

This study employed the Statistical Process Control (SPC) method to address production quality issues effectively. SPC is a systematic approach to controlling and monitoring the entire production process. It utilizes seven basic quality control tools to analyze production processes comprehensively [35]. By implementing SPC, this study identified key production challenges and provided insights into maintaining high-quality standards. Critical aspects of the production process were evaluated using Critical to Quality (CTQ) criteria [36], standardized by the company, and Input-Process-Output (IPO) diagrams to illustrate the flow of activities in the production system. Among the seven quality control tools, the study emphasized the use of control charts, Pareto diagrams, and Fishbone diagrams to analyze defects and identify their root causes on the production floor [37].

Once the activities and potential errors were identified, a systematic prioritization of corrective actions was performed using the Failure Mode and Effect Analysis (FMEA) approach. FMEA was chosen for its structured and practical methodology in pinpointing the sources of errors and assessing their impact [38]. This method evaluates the severity, occurrence, and detection levels of potential failures, linking these factors to the CTQ standards established by the company. The outcome of FMEA is a prioritized list of problems based on their Risk Priority Number (RPN), which is calculated by multiplying the severity, occurrence, and detection scores. The RPN highlights critical issues requiring immediate corrective measures, particularly in production processes that rely on traditional methods without complex workflows.

Process Identification

The Process Identification stage is critical for understanding and analyzing the production workflow to detect inefficiencies and potential defects systematically. This stage involved a comprehensive review of the production process for Batik Tanah Liek, ensuring that all essential components, activities, and interactions were mapped and evaluated. The primary tool utilized for this purpose was the Input-Process-Output (IPO) Diagram, which provided a structured framework to represent and analyze the production workflow. Furthermore, the Critical-to-Quality (CTQ) approach was applied to identify quality attributes essential to meeting both customer expectations and company standards. By linking these attributes to specific stages of the production process, the study ensured that critical areas were given priority during subsequent quality improvement initiatives.

Mapping Potential Defects

To further enhance the understanding of the process, the brainstorming sessions conducted during this stage involved a diverse group of stakeholders, including artisans, supervisors, and company owners. These sessions identified potential defects or errors at each stage of production, which were then categorized into five main areas such as human factors, machinery/equipment, materials, methods and environment. The results of these brainstorming sessions, combined with insights from the IPO diagram, laid the groundwork for a deeper investigation into root causes using advanced quality control tools like Pareto diagrams and Fishbone diagrams. The results of these brainstorming sessions, combined with insights from the IPO diagram, laid the groundwork for a deeper investigation into root causes using advanced quality control tools like Pareto diagrams and Fishbone diagrams.

Failure Mode and Effect Analysis (FMEA)

The Failure Mode and Effect Analysis (FMEA) method was utilized in this study to systematically identify, assess, and prioritize the potential causes of defects within the Batik Tanah Liek production process. This approach involves a detailed evaluation of three critical dimensions: Severity, Occurrence, and Detection. Severity assesses the potential impact of a defect on the final product or process. Severity is rated based on the seriousness of the consequences, with higher scores indicating more significant impacts on product quality or customer satisfaction. For example, defects that render a batik piece unsellable or severely compromise its aesthetic value are assigned higher severity scores. Occurrence (O) evaluates the likelihood or frequency of a particular defect occurring. It considers factors such as the stability of raw materials, consistency of worker performance, and reliability of machinery. Higher scores are assigned to causes that are more likely to occur based on historical data or observed trends in the production process. Detection (D) refers to the ability of the current system to identify a defect before it affects the final product. Lower detection capability, such as insufficient quality checks or manual inspection errors, results in higher detection scores. For example, defects that go unnoticed due to inadequate inspection tools or procedures receive high detection scores. Each identified potential defect was analyzed using these three dimensions, and an RPN (Risk Priority Number) was calculated for each failure mode using the formula: RPN = Severity (S) × Occurrence (O) × Detection (D) The RPN provides a quantitative measure of risk, helping prioritize the causes of defects that require immediate attention.

To ensure accuracy and reliability in the FMEA process, the identification of defect causes began with brainstorming sessions and Fishbone diagrams, which captured potential failure modes systematically, followed by validation through interviews and surveys with permanent workers directly involved in the production process. This was further reinforced by expert verification, where the company owner, recognized as an expert in production operations, reviewed and confirmed the findings to ensure alignment with real-world practices on the production floor. The analysis revealed high-risk areas with the highest Risk Priority Number (RPN) scores, such as fabric dye inconsistencies and equipment malfunctions, which were identified as significant contributors to defects. By focusing on these critical issues, corrective actions were developed and implemented, ensuring resources were effectively directed to resolve the root causes of defects.

Improvement Proposals

The highest RPN values revealed the most pressing causes of quality defects in Batik Tanah Liek production. Addressing these prioritized issues became the foundation for improvement initiatives. By systematically reducing or eliminating defects, the company aims to enhance production quality and meet customer expectations effectively. This approach underscores the potential of combining SPC and FMEA methodologies to achieve a streamlined and defect-free production process.

RESULTS AND DISCUSSION

The Production Process

The production process for creating Batik Tanah Liek is illustrated in the IPO (Input-Process-Output) diagram in Figure 1. The inputs for this process include all materials necessary for production, such as fabric, clay, dyes, wax, and color-fixing agents. The production process is composed of seven key stages.

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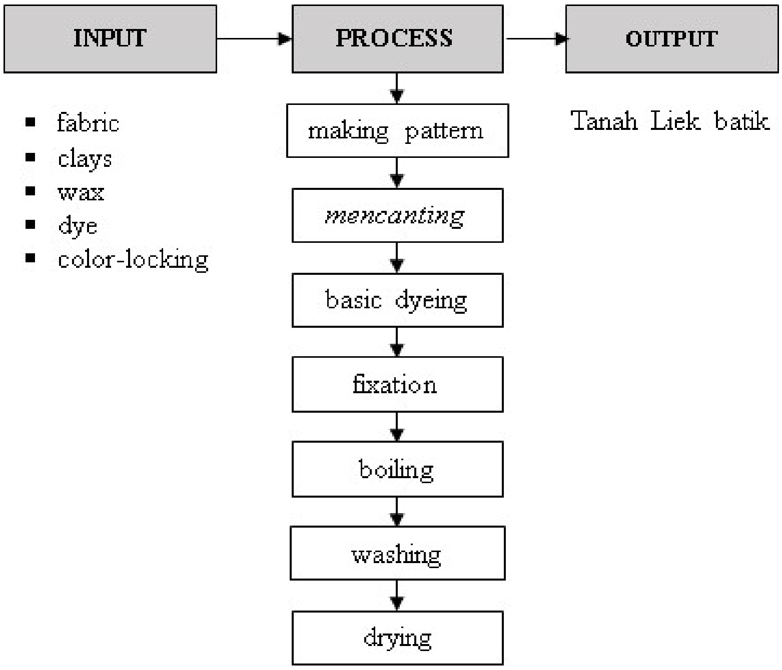

Figure 1. IPO Diagram of Batik Tanah Liek

The first stage involves creating or transferring patterns and motifs onto the fabric. This is followed by the mencanting process, where wax is applied to the fabric using a canting tool to outline the motifs. Afterward, the fabric undergoes a dyeing process, which includes applying both a base color and additional layers of color. The dyeing process may use natural materials like clay and jengkol fruit peel or synthetic dyes, depending on the desired outcome. Once the fabric is dyed, it is typically left to rest for approximately 30 minutes to allow the color to set. The subsequent stage involves color fixation, a process in which specific chemicals are applied to lock in the color and prevent fading. This step is crucial and is typically carried out overnight to ensure optimal results. Once the color is fixed, the fabric undergoes boiling to remove the wax applied during mencanting. The fabric is then washed thoroughly to eliminate any wax residues or other impurities, followed by drying under the sun. Finally, the dried fabric is ironed and packaged as a finished product. It is important to note that the batik production process does not include inspections at each individual stage. Instead, quality checks are conducted at the end of the production process, just before packaging. This approach minimizes the need for rework and streamlines the overall workflow.

Following an in-depth analysis of the batik production process, this research identified the critical factors that directly impact customer satisfaction and assessed whether the products and processes meet the desired quality standards. The identification of Critical to Quality (CTQ) aspects was achieved through a customer voice analysis, which involved gathering feedback to understand customer expectations, preferences, and requirements [36]. The company has established minimum specifications to meet internal production standards. These standards encompass key aspects such as pattern creation, mencanting, base dyeing, color fixation, boiling, washing, and drying. For instance, pattern creation requires motifs that align with consumer preferences, while the mencanting process demands that wax is applied precisely along the pre-drawn patterns.

Based on data monitored through the production control chart, several defects were identified in the process, including faded colors, torn fabric, and pattern errors. These three dominant defect types were used to define the CTQ aspects of the Batik Tanah Liek production process (Table 2). Addressing these defects is critical to ensuring that the final product meets both internal quality standards and customer satisfaction.

Table 2. CTQ of Batik Tanah Liek production process

Needs	Requirements
The color does not fade	▪ The use of dyes must comply with the existing rules ▪ The color-locking process takes longer and checks every couple of hours to ensure that the color is entirely blocked ▪ The coloring using brushes should be monitored periodically
The fabric does not tear easily	▪ The soaking or boiling process should not take too long. ▪ The drying process should not be exposed to the sun for too long.
No batik pattern errors	▪ The process of drawing patterns should be done carefully and checked periodically for the suitability of the printed motifs ▪ The use of *canting* tools must be done carefully so that the wax does not drip carelessly

Potential Defects of Batik Tanah Liek

The brainstorming process was conducted to identify potential failures or errors in the production of Batik Tanah Liek. This session brought together key stakeholders, including the business owner, employees/artisans, researchers, and a local government representative. Each participant contributed their unique perspectives and expertise to systematically address production defects. The brainstorming session was designed to generate, evaluate, and prioritize ideas, covering the entire production process—from drawing patterns to drying the batik cloth and finally ironing it for sale to consumers.

To analyze the causes of defects, a fishbone diagram was utilized. This analysis tool systematically identifies and organizes the potential root causes of defects or failures that could impact the quality of the batik cloth. The fishbone diagram provided a structured approach to pinpointing issues across various stages of production and aligning them with the specified quality standards for Batik Tanah Liek. The findings from the fishbone analysis were then used as input for the Failure Mode and Effects Analysis (FMEA) tool. FMEA further evaluated the identified causes of defects by assessing their potential impact on production and product quality. This step allowed the team to prioritize the most critical issues and address them effectively, ensuring that the production process aligns with the required standards and meets customer expectations.

Causes of Faded Batiks

Faded batiks are caused by four main contributing factors: human error, environmental conditions, methods, and materials. This defect typically occurs during the staining process, where the skill level of workers and the effectiveness of the color-locking procedure are the primary causes of rejection during quality control (QC). According to the company's internal work standards, the dyeing, color-locking, boiling, and washing processes must follow specific durations to ensure optimal results. For example, the coloring and color-locking processes should ideally be conducted overnight, while the boiling process should last for 30 minutes. However, these processes often deviate from the prescribed standards due to adjustments made to meet production targets. Observations and discussions with the business owner and workers revealed that each worker is typically assigned responsibility for a limited set of processes during their work shift, which can lead to inconsistencies in production quality. Furthermore, material-related factors, such as poor-quality fabric and wax, as well as the use of expired dyes, significantly contribute to the occurrence of faded batiks.

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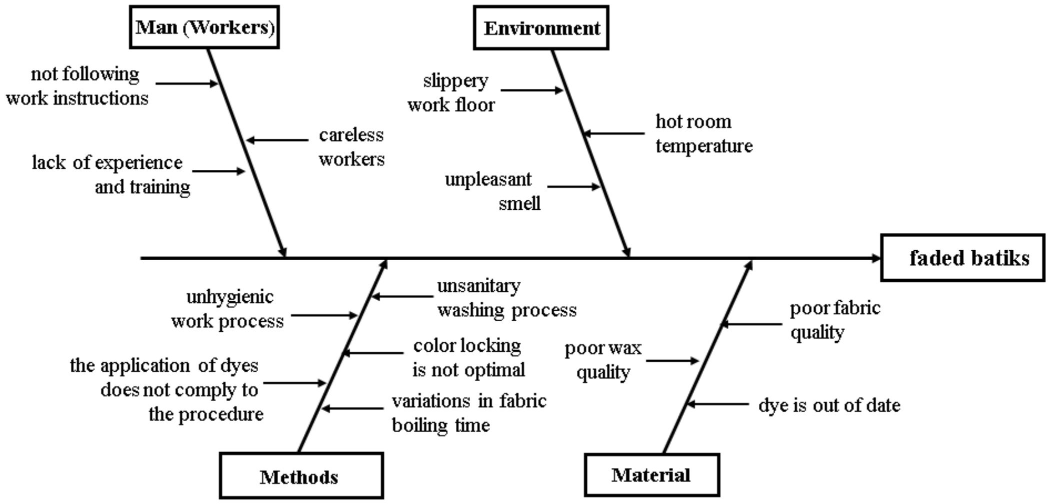
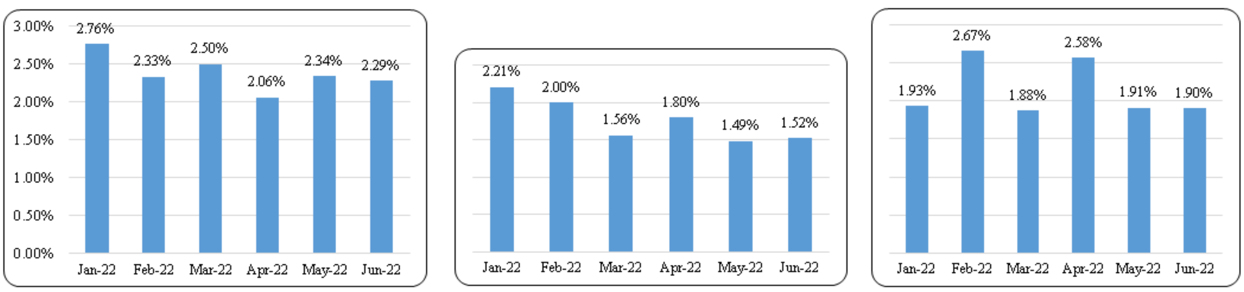


Figure 2. Fishbone diagram of faded batiks

The potential causes and effects of this defect are systematically analyzed and illustrated in the Fishbone diagram (Figure 2). Production data recorded from January to June 2022 (Figure 3) shows that faded batiks account for approximately 2.35% of the total production, making it the most frequent defect among the three identified types. This high rejection rate highlights the critical need for corrective actions to reduce defects and minimize production losses. Additionally, all contributing factors of for the three identified defect types—faded batiks, torn fabrics, and pattern or printing errors—are summarized in Table 3. This comprehensive analysis provides a clear framework for identifying and addressing the root causes of defects to improve the overall quality of Batik Tanah Liek.

Cause of torn batiks

Torn orn batiks are caused by four main factors: humans, environment, methods, and materials. Human factors include lack of experience and training, failure to follow SOPs and work instructions, rushing due to production targets, and worker fatigue from high and fluctuating demand. Environmental issues, such as poor air circulation around wax and boiling furnaces, dirty and slippery floors, and limited workspace leading to overlapping tasks, further contribute to defects. Method-related factors include the absence of standardized boiling durations and lack of periodic checks, causing fabric to deteriorate when soaked or boiled for too long. Material factors, such as low-quality fabric and unclean washing water, weaken the fabric, making it prone to tearing. As summarized in Table 3, these factors collectively result in torn batiks, which account for an average rejection rate of 1.76% of total production



(a) Defects due to faded batik (average 2,35%)

(b) defects due to torn fabric (average 1,76%)

(c) defects due to wrong pattern or printing error (average 2,15%)

Figure 3. Chart of Batik Tanak Like defects based on data from January to June 2022

Table 3. Root Causes of Batik Tanah Like Defects

Defects	Causes				
	Man	**Environment**	**Machine**	**Method**	**Material**
Faded Batik	Careless workers	Hot room temperature	-	Unsanitary washing process	Dye is out of date
	Not following work instructions			Variations in fabric boiling time	Low quality of the wax
				Unhygienic work process	
				Color locking is not optimal	
				The application of dyes does not comply with the procedures	
Torn Batik	Careless workers	Hot room temperature	-	Unsanitary washing process	Low quality of the fabrics
	Lack of experience and training	Slippery work floor		Variations in fabric boiling time	Dirty fabric
	Not following work instructions			Not optimal fabric filtration	
Wrong pattern	Careless workers	Hot room temperature	*Canting* tools are no longer usable	Unhygienic work process	The quality of the wax is not good
	Lack of experience and training	Unpleasant odor	Brushes are no longer suitable for use		
	Working feverishly to the deadline	Slippery work floor	Unclean wax cauldron		
	Not following work instructions				

from January to June 2022 (Figure 3). Reducing this rejection rate is essential to minimize production losses and improve product quality.

Causes of Pattern Errors

Pattern errors or printing defects in batik production are caused by five main factors: human error, environmental conditions, equipment issues, methods, and materials, as outlined in Table 3. The primary issue stems from the lack of regular maintenance and timely replacement of canting tools. When the canting tool's nozzle becomes too large due to wear, it becomes difficult to control the flow of wax, resulting in patterns that do not align correctly on the fabric. Additionally, the use of stiff and unsuitable brushes during the dyeing process often leads to pattern inconsistencies. Human factors, such as worker carelessness, combined with material issues like poor wax quality, further exacerbate the occurrence of pattern errors. These combined factors highlight the need for better equipment maintenance, improved worker training, and higher material standards to minimize defects and improve production quality.

Rejected Units and Total Loss

Quality control was conducted to evaluate production compliance with the company's internal standards, identifying the three most dominant defects over six months of production (January–June 2022), as detailed in Table 4. The highest proportion of rejects was attributed to faded fabric (38%), followed by pattern errors (34%) and torn fabric (28%). In total, 147 defective units were recorded, representing 6.2% of the total production of 2,365 units during

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Table 4. Rejected Units and Total Loss During the Six Months of Observation

Month	Production	Faded	Pattern error	Torn
Jan. (unit)	362	10	7	8
Feb. (unit)	300	7	8	6
Mar. (unit)	320	8	6	5
Apr. (unit)	388	8	10	7
May (unit)	470	11	9	7
Jun (unit)	525	12	10	8
Total (unit)	2365	56	50	41
Total loss (IDR)		14,000,000	12,500,000	10,250,000

Table 5. FMEA Rubric of Severity, Occurrence, and Detection scale

Scale	Severity	Occurrence	Detection
10	Dangerous without warning, production needs to be stopped, and there is no possibility to repair.	1 of 2 product	The controller unable to detect failure
9	Dangerous with a warning, production needs to be stopped, but it is still possible to repair.	1 of 3 product	The controller will rarely discover a potential failure.
8	Very high, requires a long production delay	1 of 8 product	It is pretty rare for a controller to discover a potential failure.
7	High, requiring a delay in operation and serious checking.	1 of 20 product	The probability of detecting failures is very low
6	Moderate, requiring a short delay to make repairs	1 of 80 product	The probability of detecting failures is low (<10%)
5	Low, no production delays are required, but a few rechecks are needed	1 of 400 product	The probability of detecting failures is medium (<30%)
4	Very low, defects are realized by >75% of customers	1 of 2.000 product	The probability of detecting failures is a bit high (50%)
3	Small, defects are realized by 50% of customers (50%)	1 of 15.000 product	The probability of detecting failures is high (70%)
2	Very small, defects are realized by 25% of customers	1 of 150.000 product	The probability of detecting failures is very high (85%)
1	Has no influence	1 of 1.500.000 product	Failures in the process cannot occur

this period. The monetary loss from these rejected units amounted to IDR 36,750,000. To minimize losses, the defective batik products are typically resold at lower prices or reworked to meet quality standards, where possible.

FMEA for Batik Tanah Liek Defects

The Failure Mode and Effects Analysis (FMEA) is a systematic approach used to evaluate potential causes of defects in Batik Tanah Liek production and prioritize areas for improvement. This analysis is based on data derived from fishbone diagrams, which outline potential causes of the most common defects. The process assesses three critical metrics: severity, occurrence, and detection (SOD), using a standardized scale from 1 to 10 (Table 5). Input for these metrics was collected through structured interviews with 10 employees, who provided insights into various production stages via a pre-designed questionnaire. The company owner, as an expert in Batik Tanah Liek production, reviewed and validated the data to ensure accuracy and reliability. The SOD values were averaged for each potential cause, and the Risk Priority Number (RPN) was calculated using the formula RPN = Severity ×

Table 6. FMEA for faded batik defects

Defects	Factors	Causes	S	O	D	RPN	Rank
Faded Batiks	Men (Workers)	Careless workers	4.9	2.8	2.8	38.4	7
		Not following work instructions	4.8	6.7	3.5	112.6	3
	Environment	Hot room temperature	4.2	4.8	4.1	82.7	5
	Method	Unsanitary washing process	3.5	2.8	3.1	30.4	8
		Variations in fabric boiling time	3.9	3.8	1.5	22.2	10
		Unhygienic work process	3.2	2.6	2.9	24.1	9
		Color locking is not optimal	4.1	6.4	6.6	173.2	2
		The application of dyes does not comply with the procedures	7.4	5.4	4.7	187.8	1
	Material	Dye is out of date	4.0	4.8	4.9	94.1	4
		Low quality of the wax	3.4	4.1	3.7	51.6	6

Table 7. FMEA for torn batik defects

Defects	Factors	Causes	S	O	D	RPN	Rank
Torn Batiks	Men (Workers)	Careless workers	3.2	2.8	5.1	45.7	7
		Lack of experience and training	3.1	2.9	4.6	41.3	8
		Not following work instructions	5.1	4.4	4.7	105.1	3
	Environment	Hot room temperature	2.5	5.4	3.9	52.6	5
		Slippery work floor	2.7	2.7	1.1	8.0	12
	Method	Unsanitary washing process	3.7	5.4	5.3	105.9	2
		Variations in fabric boiling time	4.9	5.3	7.2	187.0	1
		Not optimal fabric filtration	3.0	4.2	2.5	31.5	9
	Material	Low quality of the fabrics	5.3	3.9	3.6	74.4	4
		Dirty fabric	4.0	4.0	3.1	49.6	6

Occurrence × Detection. By identifying and quantifying risks, the FMEA highlights critical weaknesses in the production process, enabling targeted corrective actions to reduce defects, enhance quality, and improve operational efficiency in Batik Tanah Liek production.

For faded batik defects, the most significant cause of rejection is workers applying dyes intuitively, without adhering to the prescribed dosage. Despite the company having established procedures for dye application, these are often disregarded on the production floor. This issue has the highest Risk Priority Number (RPN=187.9), as the incorrect application of dyes directly impacts the quality of the final product. A detailed FMEA for all identified causes of faded batik defects is presented in Table 6. For torn batik defects, the primary cause is variations in fabric boiling time, which arises from differences in the type and amount of wax and dyes used for each batik fabric. This inconsistency affects the correct boiling duration and leads to fabric damage. Additional causes include an unsanitary washing process and workers failing to follow standard work instructions, both contributing to high RPN values. A comprehensive FMEA for torn batik defects is shown in Table 7. For wrong pattern defects, the highest RPN (RPN=331.8) is associated with the use of worn-out canting tools that are no longer suitable for creating precise motifs. This problem is exacerbated by the company's lack of production control over essential equipment, such as canting tools and brushes, which are critical to ensuring consistent quality. A complete FMEA for wrong pattern defects is provided in Table 8.

Recommendations

The FMEA analysis identified the highest Risk Priority Numbers (RPNs) for the primary causes of production defects—faded, torn, and incorrectly patterned batik fabric—and proposed actionable solutions to address these

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Table 8. FMEA for wrong pattern defects

Defects	Factors	Causes	S	O	D	RPN	Rank
Wrong pattern	Men (Workers)	Careless workers	5.3	4.1	5.1	110.8	3
		Lack of experience and training	3.1	3.8	4.6	54.2	7
		Working feverishly to the deadline	4.6	2.9	4.8	64.0	5
		Not following work instructions	2.6	2.4	4.8	29.9	11
	Environment	Hot room temperature	7.4	5.4	1.4	55.9	6
		Unpleasant odor	3.1	3.1	4.6	44.2	8
		Slippery work floor	3.0	2.9	4.7	40.9	9
	Machine/ equipment	*Canting* tools are no longer usable	7.4	7.6	5.9	331.8	1
		Brushes are no longer suitable for use	4.8	5.4	4.8	124.4	2
		Unclean wax cauldron	3.7	3.4	3.1	39.0	10
	Methods	Unhygienic work process	3.0	3.1	3.1	28.8	12
	Material	The quality of the wax is not good	4.9	2.8	5.0	68.6	4

Table 9. Recommendations for the critical causes of batik defect

Causes	Recommendations	Purposes
The application of dyes does not comply with the procedure	Creating work instructions at the dyeing station	A guideline for workers in dyeing processes is to obtain the right color.
	Creating sops for work in the production process	To ensure tasks and processes are performed consistently and uniformly
	Monitoring of the fabric dyeing process	Workers more orderly in carrying out their task
Variations in fabric boiling time	Creating work instructions at the boiling station	A guideline in carrying out the boiling process so that wax and dye are shed from the fabric
	Creating sops for work in the production process	To ensure tasks and processes are performed consistently and uniformly
	Monitoring of the boiling process carried out by workers	Making workers more orderly in carrying out their duties
Canting tool is no longer usable	Making of a checklist to monitor the condition of the *canting* tools	To ensure the *canting* tool functions properly and avoids wrong pattern defects
	Monitoring the *mencanting* by workers	Workers more orderly in carrying out their task

issues effectively. Key recommendations include the immediate development and implementation of detailed work instructions and Standard Operating Procedures (SOPs) for each stage of the batik production process, from pattern creation to drying and packing (Table 9). These SOPs will ensure that tasks are executed consistently and uniformly, reducing variability and maintaining high standards of quality and efficiency across all activities. Furthermore, systematic monitoring of critical processes, such as dyeing, boiling, and canting, is strongly recommended. Real-time monitoring enables the early detection of deviations or issues, facilitating prompt intervention to prevent minor problems from escalating into significant defects. Regular equipment maintenance, including timely replacement of worn-out tools like canting and brushes, should also be prioritized to sustain production quality. These measures, combined with comprehensive employee training to improve skill levels and adherence to SOPs, will not only enhance overall product quality but also minimize production losses and improve operational efficiency.

CONCLUSION

This research aimed to improve the quality of Batik Tanah Liek produced by a small artisan business (SME) by identifying and addressing key production defects that impact customer satisfaction and business sustainability. The study focused on systematically analyzing critical issues such as faded fabrics, torn fabrics, and incorrect patterns, which are the most significant contributors to product rejections. The findings revealed several high-risk causes of defects, including non-compliance with dye application procedures, inconsistent boiling times for fabrics, and the use of outdated or poorly maintained canting tools. To address these challenges, the study proposed targeted solutions aimed at improving both process consistency and worker performance. These include standardizing dye application and fabric boiling procedures through the development of clear guidelines and providing artisan training programs to ensure proper implementation. In addition, monitoring and regulating boiling temperature and time were recommended to prevent process variations, while periodic maintenance and timely replacement of canting tools were emphasized as essential to maintaining pattern accuracy and overall product quality. The implications of these findings extend beyond defect reduction. Implementing these improvements is expected to significantly enhance operational efficiency, reduce production waste, and lower costs associated with rework or product rejection. Moreover, the consistent delivery of high-quality batik products will strengthen the business's reputation, improve customer satisfaction, and build long-term customer loyalty. For the artisan business, these changes not only address immediate production challenges but also contribute to its sustainability by ensuring competitiveness in the market, creating opportunities for growth, and fostering a more efficient and professional production environment. Ultimately, this research provides a framework that other SMEs in the batik industry can adopt to enhance quality and sustain their operations in a competitive marketplace.

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CONFLICT OF INTEREST

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