

Improvement of Songkok Production Process Through Defect Analysis Using Seven Tools and Failure Mode and Effect Analysis (FMEA)

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ARTICLE INFO

ABSTRACT

Article history:

Published
March 4, 2026

Keywords:

Songkok Product
Quality Control
Defect Analysis
Seventool
FMEA

Product defects contribute to material waste, delays in delivery, and increased production costs. This study aims to identify the causes of product defects and reduce defect levels in *songkok* (traditional cap) production at CV PPI using the Seven Tools method and Failure Mode and Effect Analysis (FMEA). Data were collected in August 2025, revealing three main types of defects: untidy stitching (29.47%), inaccurate sizing (32.11%), and velvet surface defects (38.42%). Defect analysis was conducted using Seven Tools, while corrective actions were determined through FMEA by calculating the Risk Priority Number (RPN). The findings show that the highest RPN value was 210 for inaccurate sizing, followed by untidy stitching (RPN 168) and velvet surface defects (RPN 140). Improvement recommendations include stricter supervision during production, periodic evaluation of tools and materials, revision of inadequate Standard Operating Procedures (SOPs), and proper selection of velvet materials that meet quality standards to ensure product consistency and customer satisfaction.

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I. Introduction

In today's highly competitive industrial environment, companies must continuously improve product quality to maintain customer satisfaction [1]. One of the key determinants of product quality is the effectiveness of the production system [2]. Product quality can be defined as the degree to which a product conforms to predetermined specifications without defects, thereby meeting customer expectations [3], [4].

Some defective products can be repaired through rework; however, this process often leads to increased production costs and potential delivery delays, which may ultimately affect customer trust [5]. Quality control, therefore, plays a crucial role in monitoring and assessing product conformity to established standards [6]. Effective quality control not only prevents production losses but also ensures that both the process and output meet customer requirements [7], [8].

All high-quality products must meet consumer expectations. Quality is comprehensive, encompassing both the product and its processes; therefore, the consistency of a product or service's quality contributes to a company's competitive advantage in its business operations [8]. Quality is also considered a key factor in consumer decision-making regarding whether to purchase a product or not [9]. Meanwhile, quality control is defined as a system designed to maintain the quality of products or services at the desired level. This system involves monitoring product or service characteristics and implementing corrective actions whenever deviations from established standards



are identified [10]. Consistent quality control is necessary to ensure that products meet company standards. Without continuous supervision, a company risks losing customers and incurring losses [11]. The quality of a product is determined by several factors, including performance, reliability, durability, aesthetics, conformance to specifications, features, perceived quality, and serviceability [12]. Product quality can be measured by applying statistical quality control methods using statistical data [13].

CV PPI is a manufacturing company specializing in *songkok* production, located in Bungah Village, Gresik Regency. Established in 1991 and managed by Mr. Khusnul Maarif, the company distributes its products throughout Java, Sumatra, and surrounding regions, with an average production volume of 700–800 dozen units per month. However, defects still occur in the production process, which relies heavily on manual labor rather than automation. This dependency introduces various sources of defects human factors, working methods, machinery, and environmental conditions [14] which may also affect workers' morale and performance [15].

Based on observations and interviews conducted at CV PPI, several types of defects were identified, including velvet surface damage, untidy stitching, and inaccurate sizing. This research, therefore, focuses on identifying the root causes of these defects using the Seven Tools method [16] which includes check sheets, stratification, histograms, Pareto charts, cause-and-effect diagrams, scatter diagrams, and control charts [17]. Additionally, the FMEA method is employed to determine corrective action priorities based on RPN calculations [18], [19].

Each risk level is quantified by multiplying three parameters severity, occurrence, and detection [20]. Previous studies have also applied similar approaches: for instance, [21] applied Seven Tools and FMEA to wheel cylinder production, identifying eight defect indicators with a 0.73% defect rate and an RPN of 512, leading to corrective recommendations such as enhanced training and supervision. Similarly, [22] conducted defect analysis in sawdust production, identifying high moisture content as the primary defect with an RPN of 240.

The main objective of this study is to identify the causes of defects in CV PPI's *songkok* production process and provide recommendations for quality improvement using the Seven Tools and FMEA approaches [23] It is expected that this research will help minimize product defects and enhance overall production quality efficiency.

II. Method

This study applied a quantitative descriptive approach consisting of data collection, processing, and analysis stages. The research was conducted at CV PPI during August 2025. Data collection involved direct observation and interviews with both the company owner and production workers. Supporting documentation was also gathered to verify the accuracy of the information obtained.

A. Seven tools

The Seven Tools of quality management are basic instruments used to identify, analyze, and control production quality problems [24]. These tools consist of a check sheet, Pareto diagram, histogram, scatter diagram, stratification, control chart, and cause and effect (fishbone) diagram. They serve as fundamental techniques in addressing quality-related issues and identifying root causes of product defects [25].

These tools are widely used in manufacturing industries because they provide a structured and visual approach for analyzing process variability, defect distribution, and problem prioritization. They are also effective in developing a continuous improvement culture among production employees [26].

B. Failure Mode and Effect Analysis (FMEA)

Failure Mode and Effect Analysis (FMEA) is a systematic method used to identify potential failure modes, analyze their effects, and determine preventive or corrective actions [27];[28]. This technique helps detect and eliminate known and potential failures in production processes to improve reliability and reduce risks [29]. The main objective of FMEA is to prevent failures from occurring by evaluating all process stages and ensuring that corrective actions are implemented before defects reach customers.

The FMEA procedure generally involves the following steps [30]; [31]. Identify potential failure modes in each process or product component.

1. Record possible issues and their frequency of occurrence.
2. Assign numerical ratings for *severity (S)*, *occurrence (O)*, and *detection (D)*.
3. Calculate the *Risk Priority Number (RPN)* by multiplying $S \times O \times D$.
4. Rank failure modes based on their RPN to prioritize corrective actions.
5. Develop and implement recommended actions to eliminate or minimize high-risk failures.

III. Results and Discussion

In this study, the collected data included production volume, defect types, and the total number of defective *songkok* products. Details of the production data recorded during August 2025 are presented in Table 1.

A. Check Sheet

The check sheet is an effective tool used to systematically collect and record production data, presenting the daily number of *songkok* units produced along with the types and quantities of defects observed. Based on Table 1 Types of Defects in *Songkok* Products, it was found that the total number of defective products at CV PPI reached 380 units. Of these, 146 units were identified as velvet surface defects, 122 units as inaccurate sizing defects, and 112 units as untidy stitching defects.

Table 1. Types of Defects in *Songkok* Products PPI

Date (August 2025)	Types of Defects in <i>Songkok</i> Products (units)			Total Defects (units)	Defect Percentage (%)
	Untidy Stitching (units)	Inaccurate Sizing (units)	Velvet Surface Defect (units)		
1	2	1	9	12	3.16%
2	3	1	7	11	2.89%
3	3	2	5	10	2.63%
4	2	7	4	13	3.42%
5	4	6	7	17	4.47%
6	8	5	7	20	5.26%
7	5	4	5	14	3.68%
8	3	3	4	10	2.63%
9	1	5	2	8	2.11%
10	1	4	2	7	1.84%
11	2	2	1	5	1.32%
12	7	6	1	14	3.68%
13	4	8	5	17	4.47%
14	4	3	4	11	2.89%
15	3	3	4	10	2.63%
16	6	2	3	11	2.89%
17	2	2	4	8	2.11%
18	3	1	6	10	2.63%
19	7	1	6	14	3.68%
20	4	3	4	11	2.89%
21	4	9	2	15	3.95%
22	8	2	2	12	3.16%
23	6	8	3	17	4.47%
24	6	3	3	12	3.16%
25	2	5	3	10	2.63%
26	2	7	10	19	5.00%
27	1	6	9	16	4.21%
28	2	7	8	17	4.47%
29	3	1	9	13	3.42%
30	2	2	4	8	2.11%
31	2	3	3	8	2.11%
Total	112	122	146	380	99.97%
Average	3.61	3.94	4.71	12.26	0.03%

B. Pareto Diagram

The Pareto method is employed to identify the most dominant types of defects during the production process by ranking them according to their frequency, from highest to lowest [32]. In the production of songkok products, the occurrence of defects can be observed in Table 2 and Figure 2 below:

Table 2. Cumulative Frequency of Defects in Songkok Products

No	Defect Type	Total	%	Cumulative %
1	Poor stitching	112	29.47%	29%
2	Inaccurate sizing	122	32.11%	62%
3	Velvet defects	146	38.42%	100%
Total		380	100%	

From Table 2, the cumulative percentages of defects in the songkok products are as follows: velvet defects account for 38.42%, inaccurate sizing for 32.11%, and poor stitching for 29.47%.

C. Cause and Effect Diagram

This tool is used to identify the factors causing defects in songkok products, which are illustrated using a cause-and-effect (fishbone) diagram. The influencing factors include human, method, material, machine, and environmental aspects, as shown in Figure 1.

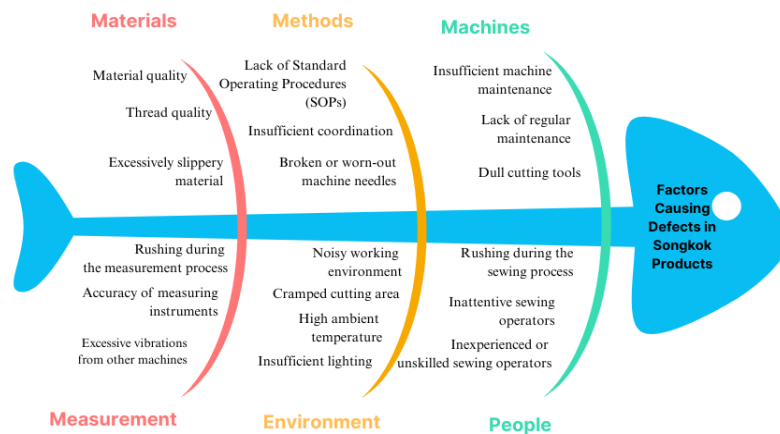


Fig 1. Factors Causing Defects in Songkok Products

D. Failure Mode and Effect Analysis (FMEA)

The risk assessment calculation presented in Table 3 is based on the following formula:

Table 3. *Failure Mode and Effect Analysis (FMEA)*

Type of Defect	Potential Effect of Failure	Potential Causes of Failure	Control Actions	S	O	D	RPN
Untidy Stitching	Irregular or uneven stitching on the <i>songkok</i> results in poor appearance and nonconformance to the product pattern.	<ol style="list-style-type: none"> Lack of machine maintenance Dull cutting tools Absence of SOPs Poor coordination Broken or worn-out sewing needle Low-quality fabric materials Noisy working environment Limited workspace for cutting Inadequate lighting Rushed sewing process Low operator skill level 	<ol style="list-style-type: none"> Provide clear instructions emphasizing the importance of precision and attention to detail during sewing. Optimize workstation layout and workflow efficiency. Conduct regular preventive maintenance and machine inspections. Educate workers on selecting appropriate needle sizes for each fabric type. 	6	4	7	168
Inaccurate Sizing	The cut parts do not match the intended pattern, resulting in inaccurate product dimensions.	<ol style="list-style-type: none"> The sewing procedures are not clearly defined. Lack of operator concentration during the measurement process. Variations in the thickness of the black felt fabric. The sewing thread used is prone to breakage. Inaccuracy or poor calibration of measuring instruments. Rushing during the measurement process, leading to errors. Inadequate lighting conditions in the workspace. Product dimensions do not match the required specifications. Low skill level and insufficient 	<ol style="list-style-type: none"> Encourage operators to maintain focus and concentration throughout the production process to ensure measurement accuracy. Improve workplace lighting by installing additional lamps at key points to enhance visibility and reduce measurement errors. Establish and implement clear Standard Operating Procedures (SOPs) for operators to ensure consistent adherence to company standards. Provide regular training sessions and motivational programs to enhance workers' technical skills and awareness of quality requirements. Develop and enforce a routine schedule for tool inspection and calibration to maintain 	6	7	5	210

Type of Defect	Potential Effect of Failure	Potential Causes of Failure	Control Actions	S	O	D	RPN
		training of sewing operators. 10. The sewing machine needle is dull or worn out.	measurement accuracy and equipment reliability.				
Velvet Surface Defects	The velvet material used is slippery and tends to fold during the cutting process, causing the fabric to shift and resulting in misalignment with the design pattern.	1. Insufficient maintenance of sewing and cutting machines. 2. Improper machine setup or calibration during fabric processing. 3. Incorrect thread insertion or tension adjustment. 4. Lack of operator focus during fabric handling and cutting. 5. Dusty and overcrowded warehouse conditions affecting fabric cleanliness. 6. Poor lighting in the workplace, reducing visibility during cutting operations. 7. High humidity levels in the storage area leading to mold growth on the fabric. 8. Rushed measuring or cutting process causing alignment errors. 9. Wrinkled or uneven fabric surface before cutting. 10. Slippery velvet material that easily shifts during cutting or stitching. 11. Misaligned velvet fibers resulting in inconsistent	1. Provide training for employees on proper cutting techniques for velvet materials, and ensure that cutting and sewing machines are regularly maintained and serviced. 2. Perform cutting operations in a spacious area using a wide, stable cutting table specifically designed for handling velvet fabric to prevent material slippage and misalignment. 3. Implement strict quality control and inspection with suppliers before delivery to ensure that the velvet materials meet the required specifications and quality standards.	4	5	7	140

Type of Defect	Potential Effect of Failure	Potential Causes of Failure	Control Actions	S	O	D	RPN
		texture and visual defects.					

Table 4. Priority Levels and Recommended Actions

Failure Mode	Potential Effect of Failure	RPN	Rank	Recommended Action	Person Responsible	Action Taken
Inaccurate Sizing	The cut sections do not match the intended pattern, resulting in dimensional inaccuracy.	210	1	<ol style="list-style-type: none"> 1. The owner should conduct specialized training programs for sewing operators. 2. The owner should implement stricter supervision throughout the production process. 3. Routine maintenance of sewing machines, scissors, and needles must be performed regularly. 4. Replace low-quality raw materials such as threads and needles with standard materials suitable for each fabric type. 5. Improve lighting conditions in the workspace to enhance operator focus and precision. 6. Provide sufficient workspace or cutting tables for material preparation. 7. Cutting operators must use standardized measuring tools. 8. The owner should verify 	Head of Department	The department head monitors the production process, communicates findings to the business owner, and conducts regular evaluations to improve equipment and material quality.

				and select reliable raw material suppliers.	
Untidy Stitching	Irregular or uneven stitching on the <i>songkok</i> results in poor product appearance and nonconformance to pattern specifications.	168	2	<ol style="list-style-type: none"> 1. Implement routine supervision to ensure correct thread tension adjustment. 2. The owner should ensure the use of high-quality satin or lining materials. 3. Provide workers with adequate rest periods to prevent fatigue and rushed work. 4. Ensure that spare threads and needles are readily available when needed. 5. Conduct daily evaluation of sewing performance and output quality. 6. Replace dim or malfunctioning lights to maintain proper visibility. 	Head of Sewing Division The sewing department head conducts periodic supervision, reviews existing SOPs, and recommends revisions where necessary to achieve consistent stitch alignment. Immediate corrective actions are communicated to the owner for prompt implementation.
Velvet Surface Defects	The velvet fabric is slippery and tends to fold during the cutting process, causing misalignment with the design pattern.	140	3	<ol style="list-style-type: none"> 1. Ensure proper ventilation in the production area to maintain air circulation and operator comfort. 2. Implement a shift rotation system to minimize operator fatigue during repetitive work. 3. Provide an enclosed and clean workspace to prevent dust accumulation on velvet materials. 4. Strengthen inspection and quality control 	Head of Sewing Division The sewing department head is responsible for verifying and ensuring that the velvet materials used meet the required quality standards and specifications through coordination with the business owner.

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- processes during production.
 - 5. Coordinate with suppliers to guarantee that velvet materials meet quality standards.
 - 6. Provide high-quality needles and threads to improve stitching performance.
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As shown in Table 4, the analysis revealed that the inaccurate sizing defect recorded the highest Risk Priority Number (RPN) of 210, corresponding to a severity score of 6, an occurrence score of 7, and a detection score of 5. This result highlights the need for immediate corrective measures to mitigate production losses due to product rejections and to prevent the recurrence of this failure mode in subsequent manufacturing cycles.

IV. Conclusion

Based on the results of the study, quality control analysis of songkok products using the Seven Tools and Failure Mode and Effect Analysis (FMEA) methods revealed that the most dominant defects were velvet surface defects (146 units), inaccurate sizing (122 units), and untidy stitching (112 units). The primary factors contributing to these defects include human error, machine performance, work methods, environmental conditions, raw material quality, and measurement inaccuracies. The FMEA results indicated that the highest Risk Priority Number (RPN) value of 210 was associated with the inaccurate sizing defect. Therefore, several corrective actions are recommended: operators should maintain focus and attention during their work, improve lighting conditions in dark work areas, establish and implement clear Standard Operating Procedures (SOPs) to ensure compliance, provide regular training and motivation programs for workers, and develop a routine schedule for equipment inspection and maintenance. These measures are expected to minimize potential failure risks and enhance overall product quality in the songkok production process.

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