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Quality Control Analysis to Minimize Defective Products Using the Failure Mode and Effects Analysis (FMEA) Method in the Karya Raharja Village-Owned Enterprise (BUMDES) Convection Business

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Abstract. The convection business unit operated by BUMDes Karya Raharja, located in Galudra Village, Pondok Salam Subdistrict, Purwakarta Regency, continues to face a high defect rate, averaging 15.52% per month, due to limited resources, the absence of standard operating procedures (SOPs), and a quality control system that has not been implemented optimally. This study aims to identify the failure modes occurring in the convection production process, assess their risk levels using the Failure Mode and Effect Analysis (FMEA) method, and formulate improvement proposals to reduce the defect rate. A descriptive case-study approach with a mixed-method design was employed, combining quantitative data on production and defect volumes with qualitative data obtained through observation and interviews across four production stages: cutting, sewing, finishing, and packing. Process FMEA (PFMEA) was applied to calculate the Risk Priority Number (RPN) for each failure mode, followed by the development of corrective actions using the 5W+1H approach. The results identified six failure modes with RPN values ranging from 108 to 280. Four failure modes were categorized as high priority (RPN ≥ 200): defective/stained fabric passing through to the finishing stage (RPN 280), loose or broken sewing thread (RPN 256), untidy stitching (RPN 252), and cut-fabric dimensions not matching the pattern (RPN 210). The sewing and finishing stages were identified as the critical points in the production process. The resulting improvement proposals are practical and do not require significant investment or complex systems. This study demonstrates that FMEA can be effectively applied in a resource-limited, village-owned enterprise (BUMDes) convection business.

Keywords: *Quality Control, Defective Products, Failure Mode and Effect Analysis (FMEA), Risk Priority Number (RPN), convection industry, BUMDes.*

A. INTRODUCTION

The garment industry is a business sector that plays a vital role in supporting the local economy, particularly at the village level. Micro, Small, and Medium Enterprises (MSMEs), including village-based garment businesses, are known to contribute significantly to national economic growth by absorbing labor and increasing community income (Brassard & Ritter, 2016; Group & Automobilindustrie, 2019; Hidayat et al., 2022; Rausand & Haugen, 2020). As demand for ready-made clothing increases, demands for product quality are also increasing, requiring every garment business unit to have a robust quality control system to compete and maintain customer trust (Meresa & al., 2025; Sundari et al., 2021; Yuganta et al., 2024).

Product quality is a key determinant of a business's sustainability. According to (Heizer et al., 2022), quality is the totality of a product's characteristics that support its ability to meet specified needs. Quality control is not merely a final product inspection activity, but rather a system that must be implemented comprehensively at every stage of the production process, from the receipt of raw materials to the product being ready for distribution (Evans & Lindsay, 2020; Goetsch & Davis, 2022; Hakim & Al-Faritsy, 2024; Montgomery, 2020). Without a structured quality control system, the risk of production process failure in the form of defective products will be difficult to detect and prevent early on.

Karya Raharja Village-Owned Enterprise (BUMDes) is a business entity owned by Galudra Village, Pondok Salam District, Purwakarta Regency, one of whose business units is engaged in the garment industry. As a village-based business with limited resources, both in terms of operator skills, standard operating procedures (SOPs), and quality control systems, this business unit still faces various obstacles in maintaining consistent product quality. The garment production process involves a series of interrelated stages, from fabric cutting, sewing, finishing, to packaging, each of which has a different potential risk of process failure. Preliminary data shows that the defect rate of Karya Raharja Village-Owned Enterprise (BUMDes) garment products averages 15.52% per month, resulting in waste of raw materials and production time due to the need for rework, and potentially reducing customer trust.

To overcome these problems, an analytical approach is needed that is able to identify various failure modes at each stage of the production process, while also providing a quantitative assessment of the level of risk (Dzikri et al., 2024; Purnomo et al., 2023; Sya'bani & Herwanto, 2024). One method that can be used is Failure Mode and Effect Analysis (FMEA), which is a method used to identify, evaluate, and prioritize potential failure modes in a system or process based on the Risk Priority Number (RPN) value, which is obtained from the multiplication of the severity level, frequency of occurrence, and detection capability (Stamatis, 2003). The higher the RPN value of a failure mode, the greater the priority for repair that must be given.

Various previous studies have proven the effectiveness of the FMEA method in identifying and reducing the risk of process failure in various types of industries, including small and medium industries with limited resources, whether applied independently (Andriyani & Rumita, 2017) or combined with other methods such as Six Sigma (Hakim & Al-Faritsy, 2024; Purnomo et al., 2023), Statistical Process Control (Alifka & Apriliani, 2024), and (Yovita et al., 2019). A systematic review by (Akhyar, 2020) also confirmed that the application of FMEA in various industrial sectors continues to develop and has consistently proven effective in identifying and prioritizing failure modes, including in the sewing-based industry (Yovita et al., 2019). However, research that specifically applies the FMEA method to Village-Owned Enterprises (BUMDes)-based convection business units is still very limited, so this study is expected to fill this gap and provide a practical contribution to the development of quality control systems in village-based convection businesses.

Based on the description, this study aims to: (1) identify failure factors that cause defective products in the convection production process at BUMDes Karya Raharja; (2) apply the FMEA method to assess the level of risk of failure in the production process based on the RPN value; and (3) prepare improvement proposals to reduce the risk of process failure and improve the quality of convection production at BUMDes Karya Raharja.

B. METHOD

The object of this study was the garment production process at the BUMDes Karya Raharja business unit, located in Galudra Village, Pondok Salam District, Purwakarta Regency, West Java, Indonesia. The PFMEA analysis focused on the four production stages that contributed most significantly to product defects: fabric cutting, sewing, finishing, and packing. Data were collected through observations, interviews, and documentation conducted during the research period. Historical production and defect records from August 2025 to July 2026 were analyzed, while production cost analysis and demand forecasting were excluded from the scope of this study.

This study employed a descriptive research approach using a case study method, which investigates a contemporary phenomenon in depth within its real-life context (Yin, 2018). The research also adopted a mixed-methods design by integrating quantitative data, including production output, defective product records, and Risk Priority Number (RPN) calculations, with qualitative data obtained through observations and interviews regarding the causes of failures in the production processs (Sugiyono, 2019). The primary analytical method was Process Failure Mode and Effects Analysis (PFMEA). The findings were subsequently translated into corrective action recommendations using the 5W+1H framework (What, Why, Where, When, Who, and How) to ensure that the proposed improvements were practical and implementable.

Data were collected using three complementary methods to achieve data triangulation:

1. Direct observation was conducted in the cutting, sewing, finishing, and packing areas to examine machine conditions, work procedures, and operator practices.
2. Semi-structured interviews were carried out using purposive sampling with the BUMDes manager, senior sewing operators, and the quality control (QC) supervisor to identify the causes of production defects and evaluate the existing quality control system. The interview results also served as the basis for assigning the Severity (S), Occurrence (O), and Detection (D) ratings in the PFMEA analysis (Montgomery, 2020).
3. Document analysis involved reviewing monthly production and defect reports, standard operating procedures (SOPs), and relevant scientific literature.

The collected data were analyzed using the Process Failure Mode and Effects Analysis (PFMEA) method following the procedures recommended by Montgomery (2020), and Rausand & Haugen (2020). The analysis consisted of the following steps:

1. Establishing an FMEA team consisting of the BUMDes manager, sewing operators, and the QC supervisor;
2. Mapping the production process and identifying the function of each production stage;
3. Identifying potential failure modes at each stage of production;
4. Analyzing the effects of each failure mode on product quality and customer satisfaction;
5. Identifying the causes of each failure mode and evaluating the existing control measures;
6. Assigning Severity (S), Occurrence (O), and Detection (D) scores on a scale of 1 to 10 for each failure mode through discussions with the selected respondents, followed by calculating the Risk Priority Number (RPN) using the following equation:
$$RPN = \text{Severity } (S) \times \text{Occurrence } (O) \times \text{Detection } (D)$$
7. Ranking the failure modes according to their RPN values to determine improvement priorities.

Failure modes with RPN ≥ 200 were classified as high priority and required immediate corrective action. Failure modes with RPN values between 100 and 199 were categorized as medium priority and scheduled for improvement, while those with RPN < 100 were considered low priority and subjected to routine monitoring.

Failure modes with the highest RPN values were used as the basis for developing corrective action proposals using the 5W+1H framework (Purnomo et al., 2023). This framework specifies:

1. What – the primary improvement objective;
2. Why – the rationale for the proposed corrective action based on the RPN results;
3. Where – the location where the improvement should be implemented;
4. When – the implementation schedule;
5. Who – the personnel responsible for implementation; and
6. How – the technical procedures for carrying out the corrective action.

Applying the 5W+1H framework ensured that the proposed improvements were practical, systematic, and readily implementable by both production operators and BUMDes management.

C. RESULT AND DISCUSSION

1. Object Profile and Production Data

Karya Raharja Village-Owned Enterprise (BUMDes) is a village-owned enterprise in Galudra Village, Pondok Salam District, Purwakarta Regency. One of its business units is engaged in the garment industry, producing various types of clothing according to customer requests. The production process is not supported by written standard operating procedures (SOPs) or standard inspection checklists, thus various failure modes have the potential to recur without early detection. A summary of production data and product defects for the period August 2025 to July 2026 is presented in Table 1.

Table 1. Recapitulation of Production Data and Product Defects for the Period August 2025-July 2026

Month	Total Production (Pcs)	Total Defective Products (Pcs)	Reject Rate (%)
August 2025	6,814	1,056	15.50
September 2025	6,923	1,114	16.09
October 2025	6,863	1,043	15.20
November 2025	6,744	1,076	15.95
December 2025	6,771	887	13.10
January 2026	7,079	1,050	14.83
February 2026	6,976	1,139	16.33
March 2026	6,974	1,083	15.53
April 2026	6,842	1,098	16.05
May 2026	6,793	1,020	15.02
June 2026	6,957	1,109	15.94
July 2026	7,145	1,190	16.66
Total	**82,881**	**12,865**	**15.52**
Average	**6,906.75**	**1,072.08**	**15.52**

Source: BUMDes Karya Raharja documentation, 2026, processed by the author

Based on Table 1, total production for 12 months reached 82,881 pieces with an average of 6,906.75 pieces per month, while the total number of defective products was recorded at 12,865 pieces or an average of 1,072.08 pieces per month, resulting in an average reject percentage of 15.52% per month. The highest reject rate occurred in July 2026 (16.66%) and the lowest in December 2025 (13.10%), but overall the defect rate was relatively stable at around 13%-17% throughout the observation period, without showing a significant improvement trend. In terms of the contribution of defect-causing categories, the sewing error category was the largest contributor (30.04%), followed by incorrect cutting (27.02%) and untidy finishing (12.12%), which confirms that the sewing and cutting stages are the most dominant sources of defects.

2. FMEA Process Mapping and Assessment

Based on observations and interviews with BUMDes managers, senior sewing operators, and quality control personnel, six failure modes were identified across four stages of the production process (cutting, sewing, finishing, and packing). Each failure mode was assessed based on Severity (S), Occurrence (O), and Detection (D), then the RPN value was calculated = S x O x D. The results of the FMEA worksheet are presented in Table 2.

Table 2. FMEA Worksheet for the Convection Production Process

No.	Process Stage	Failure Mode	Failure Effect	Potential Cause(s)	Current Control	S	O	D	RPN	Priority
1	Cutting	Fabric dimensions do not match the cutting pattern	Components become inaccurate, leading to rework during sewing or product rejection	Pattern shifts during tracing, fabric slips during cutting, insufficient operator accuracy	Occasional visual inspection conducted by the cutting operator	7	5	6	210	4
2	Sewing	Uneven stitching (misaligned with the sewing line)	Poor product appearance and potential customer complaints	Operator inaccuracy and improper sewing machine thread tension	Operator inspects the first completed piece; no standardized inspection checklist	6	7	6	252	3
3	Sewing	Sewing thread easily loosens or breaks	Reduced product durability and increased customer returns	Inappropriate thread type or quality for the fabric and incorrect overlock machine settings	No specific control; defects are usually detected only after customer complaints	8	4	8	256	2
4	Finishing	Defective or stained fabric passes the final inspection	Defective products reach customers, reducing customer confidence	Stains from previous processes are difficult to detect due to inadequate lighting in the finishing area	Visual inspection by a single QC inspector without standardized lighting or checklist	8	5	7	280	1
5	Finishing	Loose threads are not removed	Untidy product appearance and lower perceived quality	Limited finishing time; operators rush to meet production targets	Brief visual inspection before packing	4	6	5	120	5
6	Packing	Incorrect product size packed	Customer complaints, product returns, and additional shipping costs	Inconsistent size labeling and omission of final label verification before packing	No label rechecking before packaging	6	3	6	108	6

Source: results of observations, interviews, and assessments of the FMEA team, 2026

As an example of the calculation, the failure mode of defective/stained fabrics passing through to the final stage of finishing received a Severity score of 8 (a major impact on customer trust), Occurrence score of 5 (occurs quite frequently), and Detection score of 7 (difficult to detect because inspection controls are not yet standardized), resulting in an RPN value of 8 x 5 x 7 = 280, the highest RPN value among all identified failure modes. Four of the six failure modes originate from two sequential stages, namely sewing and finishing, so these two stages can be said to be critical points in the production process of the Karya Raharja BUMDes convection. In general, all failure modes have similar root causes, namely the lack of written SOPs and standard inspection checklists, and controls that still rely on momentary visual inspections by the operators themselves without a double verification mechanism. The generally high Detection score (ranging from 5-8) for most failure modes also indicates that the ability to detect defects before they reach the customer is still low, so strengthening detection controls is one of the main areas of improvement that needs to be prioritized.

3. Determining Priorities Based on RPN Values

The RPN values obtained are then sorted from highest to lowest to determine the priority of corrective actions, as presented in Table 3.

Table 3. Recapitulation and Prioritization of Improvements Based on RPN Values

Rank	Process Stage	Failure Mode	RPN	Priority Category
1	Finishing	Defective or stained fabric passes the final inspection	280	High – Immediate corrective action required
2	Sewing	Sewing thread easily loosens or breaks	256	High – Immediate corrective action required
3	Sewing	Uneven stitching (misaligned with the sewing line)	252	High – Immediate corrective action required
4	Cutting	Fabric dimensions do not match the cutting pattern	210	High – Immediate corrective action required
5	Finishing	Loose threads are not removed	120	Medium – Corrective action should be scheduled
6	Packing	Incorrect product size packed	108	Medium – Corrective action should be scheduled

Source: FMEA data processing results, 2026

The results of the RPN value sorting show that four failure modes, namely defective/stained fabrics that pass to the final stage (RPN 280), sewing threads that are easily loose/broken (RPN 256), untidy stitching (RPN 252), and the size of the cut fabric that does not match the pattern (RPN 210), are included in the high priority category and need to be followed up immediately, while the remaining thread is not cleaned (RPN 120) and the product size is exchanged in the packaging (RPN 108) are included in the medium priority category. It is interesting to note that the failure mode of defective/stained fabrics at the finishing stage occupies the highest priority even though its contribution to the total defects based on 12 months of data is relatively not the most dominant. This occurs because the RPN value is not only determined by the frequency of occurrence (Occurrence), but also by the severity (Severity) and detection ability (Detection). On the other hand, the sewing error category which is most dominant in frequency is represented by two failure modes at the sewing stage which are ranked second and third, so that in general the sewing and finishing stages are the areas with the highest risk of process failure which need to receive primary attention.

4. Proposed Improvements with the 5W+1H Approach

Referring to the results of the priority determination in Table 3, proposed corrective actions were prepared for the four failure modes with high priority categories using the 5W+1H approach, as presented in Table 4.

Table 4. 5W+1H Improvement Proposal for High Priority Failure Modes

Failure Mode (RPN)	What	Why	Where / When	Who	How
Defective or stained fabric passes the final inspection (280)	Implement a standardized inspection checklist for defective or stained fabric, supported by adequate lighting standards	Highest RPN value; poor Detection (7) and high Severity (8), posing a significant risk to customer satisfaction and trust	Finishing area/Beginning with the next production cycle	QC supervisor and finishing operators	Install additional lighting at inspection stations, introduce a standardized inspection checklist, and conduct double-check inspections before packing
Sewing thread easily loosens or breaks (256)	Standardize thread type and quality according to fabric specifications and perform routine overlock machine calibration	High RPN value; both Severity (8) and Detection (8) are high, with no dedicated preventive control currently in place	Sewing/overlock area/At the beginning of each new production batch	Overlock machine operators and production manager	Develop a thread selection reference table, establish a machine calibration schedule, and perform tensile testing on sample stitches
Uneven stitching (misaligned with the sewing line) (252)	Develop written sewing SOPs for each product model, accompanied by operator self-inspection checklists	High RPN caused by operator inaccuracy and inconsistent thread tension settings	Sewing area/At the beginning of every shift and whenever production changes to a new product model	Sewing operators and production supervisor	Conduct briefings on standard thread tension settings, implement self-inspection checklists, and provide periodic refresher training
Fabric dimensions do not match the cutting pattern (210)	Introduce double-check verification of cutting patterns before cutting and use standardized cutting guides and fabric clamps	High RPN resulting from pattern displacement and fabric movement during cutting	Cutting area/Before every cutting operation	Cutting operators and production supervisor	Use standardized cutting guides/templates, apply fabric clamps to prevent movement, and require two-person verification before cutting begins

Source: Author's analysis results, 2026

The proposed improvements in Table 4 are directed at addressing the main root causes of each high priority failure mode. At the finishing stage, the addition of inspection table lighting and standard checklists is expected to reduce the Detection value, so that defects can be recognized early before the product continues to the packing stage. At the sewing stage, standardization of thread types and calibration of overlock machines targets two root causes at once, while the preparation of written sewing SOPs and self-inspection checklists is expected to reduce Occurrence values which are currently relatively high. At the cutting stage, the use of cutting guides, cloth clamps, and verification by two people before cutting is expected to reduce the Occurrence and Detection values for the related failure modes (Krajewski et al., 2019; Stevenson, 2018; Tjiptono & Diana, 2020). The four proposed improvements are prepared in an applicable manner by considering the causes of failure and current control conditions, so that they can be directly followed up by the management and operators of BUMDes Karya Raharja without requiring investment or complex systems. By consistently implementing these proposed improvements at the cutting, sewing and finishing stages, it is hoped that the defect rate for convection products, which currently averages 15.52% per month, can be reduced gradually.

D. CONCLUSION

Based on the results of data collection, processing, and analysis, several conclusions can be drawn as follows. First, based on the results of observations, interviews, and Process FMEA mapping at four stages of the convection production process (cutting, sewing, finishing, and packing) at BUMDes Karya Raharja, 6 (six) failure modes were identified as the main causes of defective products, all of which stem from similar root causes, namely the absence of SOPs and standard inspection checklists, as well as quality control that still relies on momentary visual inspection without a double verification mechanism. Second, the application of the FMEA method has been proven to be able to be used to assess the level of risk of failure in the convection production process quantitatively through the calculation of the RPN value, with the RPN values obtained ranging from 108 to 280. Four failure modes are categorized as high priority (RPN ≥ 200), namely defective/stained fabrics that pass to the final stage (RPN 280), sewing threads that are easily loose/broken (RPN 256), untidy stitching (RPN 252), and the size of the cut fabric that does not match the pattern (RPN 210), while the sewing and finishing stages are indicated as critical points in the production process. Third, the improvement proposals prepared using the 5W + 1H approach to the four high-priority failure modes are applicable, do not require investment or complex systems, and can be directly followed up by the managers and operators of BUMDes Karya Raharja to reduce the level of defects in convection products which currently averages 15.52% per month. This study shows that the FMEA method can be applied effectively to a village-owned enterprise (BUMDes)-based convection business with limited resources, thus producing a structured analysis as well as concrete and easily implemented improvement proposals. Further research is recommended to expand the scope of the Process FMEA analysis to other stages of the production process such as order acceptance and raw material receipt, combine the FMEA method with other methods such as Six Sigma or Statistical Process Control (SPC), and consider the cost aspect (cost-benefit analysis) of each improvement proposal submitted.

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