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Implementation of Product Quality Improvement Using the Six Sigma Method (DMAIC) to Minimize Defects in the Reusable Diaper Industry

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Abstract

Reusable diapers are becoming an increasingly popular eco-friendly option, but the industry faces challenges in maintaining product quality for customer satisfaction. This study analyzes and improves the quality of reusable diapers using the Six Sigma method using the DMAIC (Define, Measure, Analyze, Improve, Control) approach. In the Define stage, quality issues are identified through customer complaints and product inspections. The Measure stage involves collecting defect data and analyzing it using control charts. The Analyze stage utilizes Fishbone Diagrams and FMEA to identify the root causes of defects. In the Improve stage, production process improvements are made, including raw material control and standard work procedures. The Control stage ensures continuous improvement through the implementation of SOPs and regular monitoring. The results show a DPMO value of 28,577 with a sigma level of 3.41, meaning that out of 1,000,000 products, there are potentially 28,577 defects. The implementation of Six Sigma has proven effective in improving the quality of reusable

Introduction

The demand for high-quality products is increasing in the modern era, particularly in the consumer goods industry. One product experiencing increasing demand is reusable diapers, which have become an environmentally friendly alternative as public awareness of the negative impacts of disposable products increases. Many parents choose reusable diapers because they are considered more environmentally friendly and safer for children's health. However, despite their various advantages, issues related to product quality remain a challenge that requires serious attention. Analyzing efforts to improve the quality of reusable diaper products is crucial to meet consumer expectations and increase industry competitiveness. (Khalisan & Hasibuan, 2025).

According to the Central Bureau of Statistics (2022), approximately 30% of consumers reported dissatisfaction with the quality of the diapers they use, resulting in product returns and consumer complaints (Gamal & Ahmed, 2018). This data demonstrates a gap between consumer expectations and the resulting product quality, thus providing an important basis for this research. Product quality is one of the main factors determining the level of customer satisfaction, which includes aspects of absorbency, comfort, durability, and ease of use. If product quality does not meet consumer expectations, this can impact brand reputation and decrease customer trust. (Hermansyah et al., 2024)

Based on production data at CV. ABC, in February 2025, the number of defective products reached 1,764 units out of a total production of 25,390 units, with an average defect rate of 7%, with the highest defect rate occurring in the fourth week at 9%, while the lowest rate of 5% occurred in the second week. This is despite the company setting a maximum tolerance limit

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of 5% for each production. This high defect rate is caused by various factors, such as unstable sewing machine performance, limited production time due to high targets, and the accuracy of the workforce during the production process (Lingkon et al., 2024; Joy et al., 2024; Tan et al., 2025).

Therefore, it is necessary to implement effective methods to improve product quality, one of which is through the application of the Six Sigma method. Six Sigma is a data-driven quality improvement method aimed at systematically reducing variation and defects in the production process (A. Mittal et al., 2023; Mansour et al., 2025; Hoggas et al., 2025). This method uses the DMAIC (Define, Measure, Analyze, Improve, Control) approach as a continuous improvement framework, which helps companies identify, analyze, and resolve product quality issues appropriately (Scavarda et al., 2025; Fantozzi et al., 2025; Carneiro et al., 2025).

In this study, the Six Sigma method with the DMAIC approach was applied to analyze and improve the quality of reusable diaper products. This research is expected to contribute to improving product quality to meet consumer expectations and increase the reusable diaper industry's competitiveness in the market.

Literature Review

Product quality improvement is a crucial aspect in the manufacturing industry, including in consumer goods industries such as reusable diapers. To support quality improvement, many companies implement the Six Sigma method, which has proven effective in reducing defect rates and increasing customer satisfaction. Six Sigma with the DMAIC (Define, Measure, Analyze, Improve, Control) approach is a method used to improve production processes by minimizing product variation and defects (Syahril et al., 2024). This approach has been widely applied in various sectors, including the textile and manufacturing industries, in an effort to achieve higher and more stable quality.

Research by (Syahril et al., 2024) entitled Quality Control Analysis to Reduce Bag Product Defects Using the Lean Six Sigma Method shows that the application of Six Sigma with the DMAIC approach can identify the root causes of defects in the bag convection industry and successfully reduce the defect rate significantly. This indicates the great potential of implementing Six Sigma in the textile and other manufacturing industries, including the reusable diaper industry which has similar challenges related to product quality.

Furthermore, (Syahril et al., 2024) revealed that the application of Six Sigma to the remanufacturing process in Indonesia was able to reduce the product defect rate from 73.5% to 7.03% in just two months, demonstrating the effectiveness of this method in improving the quality and efficiency of the production process. The application of DMAIC in various industries is evidence that this method can be used as a quality improvement strategy in the production of reusable diapers to reduce defects and significantly improve quality (Smętkowska & Mrugalska, 2018). Provides a comprehensive summary of how the Six Sigma method, specifically the DMAIC (Define, Measure, Analyze, Improve, Control) cycle, is used in various manufacturing industries to minimize defects. (Scholar et al., 2021)

Research (Fachrudin et al., 2025) on quality control of cotton yarn products using Six Sigma also showed positive results in reducing product defects. By utilizing analytical tools such as Pareto diagrams and FMEA, companies can identify the root causes of quality problems and make improvements that increase sigma levels and reduce costs due to defects. This research strengthens the relevance of Six Sigma with the DMAIC approach in improving quality in textile-based industries, including the production of reusable diapers.

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A study (Fachrudin et al., 2025) that examined the application of Six Sigma to the sewing process at CV. Suho Garmindo showed that the implementation of DMAIC can significantly improve the quality of textile products through process improvements and identification of factors causing defects, thus impacting on increasing customer satisfaction.

(Putra et al., 2024) Conducted research on the application of the DMAIC method to reduce defects in HE-EC2 electronic products at PT PIB. The results showed a decrease in the defect rate from 1.93% to 0.57%, a decrease in DPMO from 2751 to 815, and an increase in the sigma level from 4.28 to 4.65. This research proves the effectiveness of DMAIC in improving quality through precise optimization of process parameters.

In (Nusraningrum et al., 2019) the Six Sigma DMAIC method is effective in reducing the number of defects in the assembly process at PT. XYZ. The company faces a high level of defects on the assembly line, which has an impact on increasing production costs, rework, and delivery delays. The results show a significant reduction in defect rates (e.g. from ±7% to <3%), DPMO is reduced substantially, Sigma levels increase from around 2.8–3.0 to 3.5–3.6, production cost savings from reduced rework and scrap, increased productivity and delivery accuracy. Key success factors include operator training, tool improvements, and the implementation of continuous process control.

Research (Pranavi & Umasankar, 2021) explains that using the Six Sigma (DMAIC) methodology to reduce paint peel off defects on the outer panels of car hoods. The application of Six Sigma with the DMAIC cycle has been proven to be effective in overcoming the problem of paint peeling onhood outer panel.

Research by (Nur, 2024) used the Six Sigma (DMAIC) method combined with Fuzzy Failure Mode and Effect Analysis (Fuzzy FMEA) to identify and minimize defective products in the tofu production process. The combination of Six Sigma (DMAIC) and Fuzzy FMEA is effective in minimizing defects in small-scale food industries. This approach can be replicated for other small businesses with limited resources.

According to (Oprime & Sordan, 2023), the combination of DMAIC and Lean Six Sigma is very effective in reducing defects while optimizing process efficiency. The integration of lean tools such as value stream mapping and poka-yoke accelerates waste identification and prevents recurring defects.

Research by (Iskandar et al., 2025), the application of the Six Sigma methodology with the DMAIC cycle to reduce the number of reject products in the battery production process. The results show a significant decrease in the reject rate (for example, from around 9–10% to <4%), DPMO decreased drastically, indicating an increase in process capability. Then the sigma level increased from around 2.6–2.8 to 3.3–3.5 after the improvement.

Research (Hibarkah et al., 2021) on the application of Six Sigma in the sock industry also showed a decrease in the defect rate from 11.08% to 5.54%, as well as an increase in the sigma level from 3.70 to 3.96.

Similarly, research by (Salih & Salah, 2024) in the textile industry proved that Six Sigma with the DMAIC approach was able to identify and reduce raw material inventory costs by up to 70% and reduce storage costs by 55% through Pareto analysis and the implementation of a Just-In-Time (JIT) system.

Based on these various studies, it can be concluded that the application of Six Sigma with the DMAIC approach in the manufacturing industry, including the production of washable diapers, can have a positive impact on improving product quality and customer satisfaction. Therefore, companies can consider implementing this method to reduce defect rates and improve overall

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product quality. This study emphasizes the importance of implementing Six Sigma through the DMAIC approach in improving the quality of washable diaper products to meet consumer expectations and improve the company's business performance (Smętkowska & Mrugalska, 2018).

According to (Baihaqi & Baihaqi, 2023), product quality is the physical condition, function, and nature of a product, whether goods or services, based on the expected quality level such as durability, reliability, accuracy, ease of use, and ease of maintenance with the aim of meeting consumer needs and satisfaction. (Safitri & Manafe, 2024) states that product quality is the totality of features and characteristics of a product or service that are able to meet needs both explicitly and implicitly. Meanwhile, Gunawan in (Iryanti et al., 2024) emphasizes that product quality is the ability of a product to meet customer desires, including durability, reliability, and ease of use.

According to (Paper, 2019), the application of the Six Sigma DMAIC method to reduce the defect rate in the telecommunications cabinet door manufacturing process showed that the DPMO value decreased to 15,873.01 and the Sigma level increased to 3.64.

The quality of products produced by a company can vary due to various factors that influence the production process. Harjadi in (Suzann, 2020) explains that factors that influence product quality include product function, external appearance (shape, color, and packaging), and the costs incurred to obtain the product.

Gunawan in put forward several factors that influence product quality, including: factors such as raw materials, labor, machines, management and market demand have an important role in influencing the quality of products produced by the company.

Research (Shbool, 2025; Suzann, 2020) developed a Lean Six Sigma framework to prioritize the most impactful improvement areas in the packaging industry. A systematic method is needed to determine which areas should be improved first to maximize the impact on quality and efficiency. The integration of Lean and Six Sigma is effective in focusing improvement efforts on areas with the greatest impact.

Based on (Henny et al., 2021) the application of the Six Sigma method with the DMAIC approach to improve production processes and reduce defects in the manufacturing industry.bearing• The DMAIC method has proven effective in identifying the root causes of defects in the bearing industry. The combination of statistical analysis, process control, and operational improvement results in improved quality and efficiency. This approach can be adapted to other manufacturing sectors experiencing similar defect problems.

According to (Utomo, 2022), quality control aims to prevent products from not complying with previously prepared quality plans.

Quality control plays a crucial role in maintaining consistent product quality, improving production process efficiency, and ensuring customer satisfaction. Good quality control positively impacts a company's reputation and business sustainability in the face of market competition.

Six Sigma is a quality control method that uses a structured approach with DMAIC (Define, Measure, Analyze, Improve, Control) stages to reduce variation and defects in the production process (Utomo, 2022). According to (Udayana & Bukit, 2021), Six Sigma is a performance improvement approach that aims to find and eliminate the causes of defects and errors, reduce cycle time, lower operational costs, and increase customer satisfaction.

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Methods

This study adopts a quantitative descriptive approach using the Six Sigma methodology with the DMAIC framework to analyze and improve product quality in the reusable diaper production process. The research was conducted as a case study at a reusable diaper manufacturing company located in Pasuruan, Indonesia. The selection of this approach was based on the need to systematically identify sources of defects, measure production performance, analyze root causes, and propose sustainable improvements grounded in empirical production data

Research Design and Object of Study

The object of this research is the reusable diaper production process, encompassing cutting, sewing, finishing, and packaging stages. The study focuses on three product variants produced by the company, namely regular, jumbo, and snap diapers. Production and defect data from February 2025 were used as the primary basis for analysis, as this period showed defect rates exceeding the company's quality tolerance limit of five percent.

Data Collection and Processing

This study uses several data collection techniques to obtain relevant and in-depth information on product quality issues.

Table 1. Percentage of defective products

No.	Types of products	Production Quantity	Number of Defective Products	Type of Disability			
				Torn/Broken	Poor stitching	dirty	Imprecise Shape
1	Regular	9.435	597	216	239	64	78
2	Jumbo	7.685	509	192	219	31	67
3	Snap	8.270	658	241	230	78	109
Total		25.390	1.764	649	688	173	254
Presentation				36,79%	39,00%	9,81 %	14,40%

Data collection was carried out using multiple techniques to ensure the completeness and reliability of the findings. First, direct observation was conducted throughout the production floor to document actual working conditions, production flow, machine usage, and quality control practices. This method allowed the researcher to identify potential inconsistencies between standard procedures and actual implementation.

Second, semi structured interviews were conducted with production operators, quality control personnel, and production supervisors. These interviews aimed to capture practical insights regarding recurring defects, operational constraints, machine conditions, and human factors contributing to quality issues. The interview results were used to complement observational findings and strengthen the interpretation of defect causes.

Third, a literature study was undertaken by reviewing books, peer reviewed journals, and technical references related to Six Sigma, DMAIC implementation, and quality control in manufacturing industries. This step provided a theoretical foundation for selecting analytical tools and interpreting empirical results.

Data Processing and Analysis

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The collected data were processed and analyzed using the DMAIC stages of the Six Sigma methodology. In the Define stage, critical to quality characteristics were identified based on customer complaints, defect records, and production inspection data. Defects were categorized into torn or broken products, untidy stitching, dirty products, and imprecise shapes.

In the Measure stage, defect data were quantified to calculate Defects Per Million Opportunities and sigma levels for each product type and production week. Microsoft Excel was used to process numerical data and generate quality performance indicators. This stage provided an objective assessment of the initial production capability.

The Analyze stage involved identifying the dominant defect types using Pareto analysis. Cause and effect diagrams were then applied to explore the root causes of defects by grouping contributing factors into human, method, machine, and environmental categories. This analysis enabled the identification of critical sources of quality deviation within the production process.

In the Improve stage, corrective actions were formulated based on the identified root causes. Proposed improvements included operator training programs, development and implementation of standard operating procedures, preventive machine maintenance, and improvements in workplace organization and cleanliness. These actions were implemented and monitored to evaluate their impact on defect reduction.

The Control stage focused on maintaining the improvements achieved by establishing monitoring mechanisms and quality control standards. Standard operating procedures were reinforced, regular inspections were scheduled, and management involvement was emphasized to ensure that defect levels remained within acceptable limits and continuous improvement could be sustained.

Results and Discussion

Definition

This study found four types of dominant potential defects in the production process of reusable diapers which can be described as follows:

Torn or Broken Defect

The torn or broken defect emerged as one of the most structurally critical issues in the reusable diaper production process. This defect was predominantly found at the junction between the absorbent inner fabric and the waterproof outer layer, an area that inherently requires higher sewing precision due to the differing material characteristics. Field observations revealed that inaccuracies in sewing techniques were a primary contributor, particularly in maintaining consistent stitch tension and alignment across layered fabrics. In practice, operators often applied excessive overlapping stitches in an attempt to reinforce weak seams. However, rather than strengthening the joint, this practice increased localized stress on the fabric, ultimately leading to tearing or breakage. The situation was further exacerbated when sewing was repeatedly performed on the same seam area as an informal corrective measure, which unintentionally compromised fabric integrity. These findings indicate that the torn or broken defect is closely linked to a combination of technical skill limitations and informal correction practices that are not supported by standardized sewing guidelines.

Improper Stitching Defects

Improper stitching defects were identified through visibly uneven seam lines and inconsistent stitch spacing, reflecting broader challenges in maintaining sewing accuracy throughout the production process. These defects commonly occurred when fabric layers were misaligned prior to sewing or when stitch density varied significantly along the seam. A deeper

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examination of production practices revealed that limited operator proficiency and insufficient technical training played a substantial role in this issue, as operators struggled to consistently control sewing speed and stitch uniformity. In addition to skill related factors, reduced concentration during repetitive sewing tasks contributed to momentary lapses in precision, particularly under conditions of high production pressure. Machine related problems, including unstable performance and inadequate maintenance, further disrupted stitching consistency. These technical issues were compounded by the frequent use of thread materials that lacked sufficient durability, causing thread breakage and interrupted sewing flow. The absence of clearly defined standard operating procedures meant that operators relied heavily on personal judgment rather than standardized quality benchmarks. As production targets intensified, the emphasis on speed often outweighed attention to detail, reinforcing the persistence of improper stitching defects within the process.

Gross Product Defects

Unlike sewing related issues, gross product defects were primarily associated with post production handling and environmental conditions rather than core manufacturing techniques. These defects were characterized by the presence of stains, dust, residual threads, and oil marks on the product surface after the completion of sewing and before the packaging stage. Observational data indicated that inconsistencies in workplace cleanliness standards significantly influenced the occurrence of these defects. Production areas were not uniformly maintained, allowing contaminants to accumulate and come into contact with semi finished and finished products. Additionally, handling practices during inter process transfers were often carried out without adequate care, increasing the likelihood of physical contact with contaminated surfaces. Production equipment that was not regularly cleaned also served as a source of indirect contamination, transferring dirt and oil residues onto the fabric. These conditions suggest that gross product defects are symptomatic of systemic weaknesses in environmental management, cleanliness discipline, and handling protocols rather than isolated operational errors.

Imprecise Shape Defect

Imprecise shape defects reflected shortcomings originating in the early stages of the production process, particularly during fabric cutting and pattern application. These defects became evident when the final product failed to conform to predetermined dimensions and standardized design specifications. Errors in the cutting process were frequently linked to inaccurate tool usage and deviations from cutting guidelines, resulting in uneven or asymmetrical shapes. The reliability of print patterns also emerged as a contributing factor, as worn or imprecise templates led to repeated dimensional inconsistencies across product batches. Operator accuracy further influenced this defect type, as lapses in attention during pattern placement and cutting increased the likelihood of measurement deviations. Because cutting errors propagate through subsequent production stages, even minor inaccuracies at this point had a compounded impact on final product quality. These findings highlight the critical importance of precision and control at the initial stages of production to prevent downstream quality issues.

Production Data Analysis and Product Defects

Based on production data for February 2025, the total production of reusable diapers reached 25,390 units, with a total of 1,764 defective units and a defect rate of 7%. The details of this data are presented in Table 2 below:

Table 2. Production Amount for February 2025

Week 2	Date	Production quantity	Types of products	Process Results	Defect Level (%)

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				Good	Reject	Total	
1	February 2, 2025	5.250	Regular	1.897	123	2.020	6%
			Jumbo	1.409	131	1.540	9%
			Snap	1.578	112	1.690	7%
2	February 9, 2025	6.510	Regular	2.361	119	2.480	5%
			Jumbo	1.724	76	1.800	4%
			Snap	2.099	131	2.230	6%
3	February 16, 2025	5.950	Regular	2.026	129	2.155	6%
			Jumbo	1.760	105	1.865	6%
			Snap	1.756	174	1.930	9%
4	February 23, 2025	7.680	Regular	2.554	226	2.780	8%
			Jumbo	2.283	197	2.480	8%
			Snap	2.179	241	2.420	10%
Amount		25.390	-	23.626	1.764	25.390	83%
Rate-rate		-	-	-	-	-	7%

Through data analysis, researchers focused their study on the two types of defects with the highest frequency: untidy stitching (39.00%) and tearing/breaking (36.79%). These two types of defects were prioritized for further analysis for quality improvement, given their significantly higher frequency compared to other types of defects.

Measurement

Before and after product defect correction, the sigma level can be determined by entering all production and defect data into Microsoft Excel software. The results of the Six Sigma data processing before and after correction can be seen in Table 3.

Table 3. Sigma Level Before Improvement

Week 2 -	**Types of products**	**Production Quantity**	**Number of Defective Products**	**Presentation**	**DPMO**	**Level Sigma**
1	Regular	2.020	123	6%	30445,54	3,37
	Jumbo	1.540	131	9%	42532,46	3,22
	Snap	1.690	112	7%	33136,09	3,34
2	Regular	2.480	119	5%	23991,93	3,48
	Jumbo	1.800	76	4%	21111,11	3,53
	Snap	2.230	131	6%	29372,19	3,39
3	Regular	2.155	129	6%	29930,39	3,38
	Jumbo	1.865	105	6%	28150,13	3,41
	Snap	1.930	174	9%	45077,72	3,19
4	Regular	2.780	226	8%	40647,48	3,24
	Jumbo	2.480	197	8%	39717,74	3,25
	Snap	2.420	241	10%	49793,38	3,15
Total		25.390	1.764	83%	413906,21	39,96
Rate-rate				7%	34492,18	3,33

Table 4. Sigma Level After Improvement

Week 2	**Types of products**	**Production Quantity**	**Number of Defective Products**	**Presentation**	**DPMO**	**Level Sigma**
1	Regular	0	0	0	0	0
	Jumbo	0	0	0	0	0
	Snap	0	0	0	0	0
2	Regular	1.685	98	6%	29080,12	3,39
	Jumbo	1.125	54	5%	24000,00	3,48
	Snap	2.033	115	6%	28283,33	3,41
3	Regular	2.188	134	6%	30621,57	3,37

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	Jumbo	1.320	97	7%	36742,42	3,29
	Snap	2.231	103	5%	23083,82	3,49
4	Regular	2.500	128	5%	25600,00	3,45
	Jumbo	1.985	124	6%	31234,26	3,36
	Snap	1.191	68	6%	28547,44	3,40
Total		16.258	921	51,4%	257192,96	30,65
Rate-rate		-	-	5,7%	28577,00	3,41

After improvements were made in March 2025, there was a decrease in the product defect rate and an increase in the sigma level. Of the 16,258 products produced, 921 were defective, representing 5.7% and a sigma level of 3.41 (Clancy et al., 2025). In the first week, there was no production activity due to the holiday season.

Analysis

Identification and Analysis of the Causes of Product Defects in Reusable Diapers Using Pareto Diagrams and Cause-Effect Diagrams (Study et al., 2025). This study aims to identify and analyze the main sources of product nonconformity in the reusable diaper production process. Based on the results of the analysis using Pareto diagrams, it was found that the most dominant types of defects include untidy, torn or broken stitches, inappropriate product shape, and dirty product conditions.

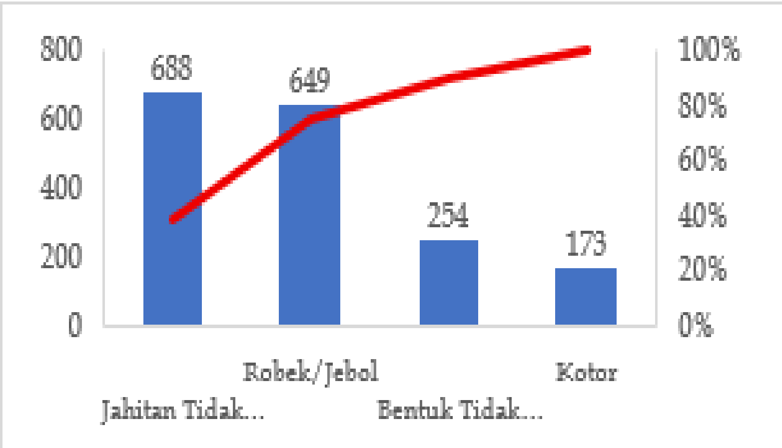

Figure 1. Pareto Chart before Improvement

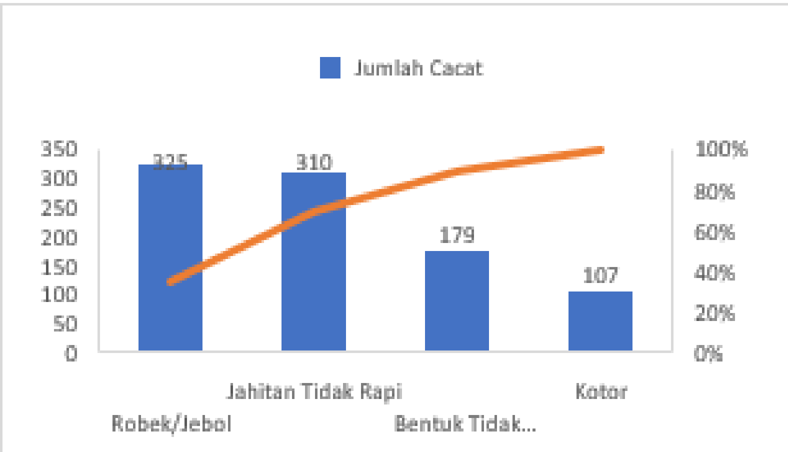

Figure 2. Pareto Chart After Improvement

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To find the root cause of these defects, further analysis was carried out using a cause-and-effect diagram (fishbone diagram), which groups the causes into four main factors: human, method, machine, and environment.

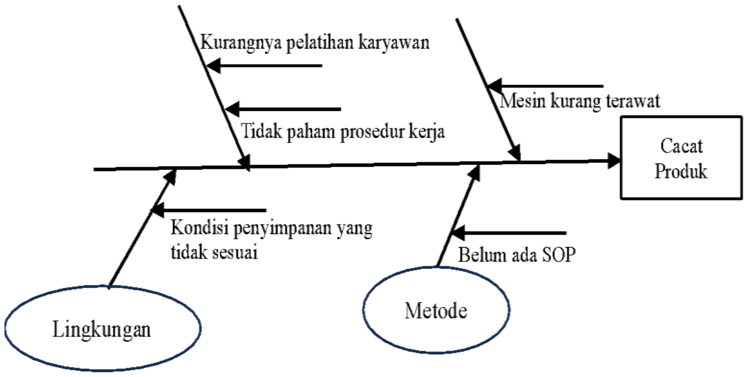

Figure 3. Cause and effect diagram

Human Factors

The largest contribution to product non conformity in the reusable diaper production process originates from human resource related factors. Observations and interview findings indicate that insufficient training has led to a limited understanding among employees regarding proper sewing techniques and the consistent application of standard operating procedures. As a result, operators tend to rely on personal habits and experiential knowledge rather than standardized technical guidelines, which increases the likelihood of procedural deviations during production. This condition weakens process consistency and creates variability in product quality across different production batches.

In addition, the lack of a comprehensive understanding of overall work procedures causes the production process to be carried out without fully adhering to the intended workflow sequence. When operators are unfamiliar with the rationale behind each production step, tasks are often performed out of order or without adequate quality checks, leading to an accumulation of minor errors that eventually manifest as defective products. These findings suggest that human resource limitations do not merely affect individual performance but systematically influence the stability and reliability of the entire production process.

Method Factor

Irregular work methods are also a major contributing factor. The lack of standard sewing procedures means each operator has a different approach, resulting in inconsistent results across products.

Machine Factors

Technical problems are also found in sewing machines that lack regular maintenance. Suboptimal machines often result in sloppy or weak stitches, which reduces overall product quality.

Environmental Factors

Environmental factors in production, particularly in the storage of materials and finished products, also contribute to quality degradation. Substandard storage, such as in humid conditions, can damage fabrics or adhesives, resulting in dirty or damaged products before they reach consumers.

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Repair

Implementing these proposed improvements is expected to significantly reduce product defect rates and improve the quality of the reusable diapers produced. Furthermore, these improvements will contribute to increased customer satisfaction and the company's long-term competitiveness. The proposed improvements include:

Human Factors

Training Program Development: Conducting comprehensive and ongoing technical training for all production operators to improve sewing skills and understanding of standard operating procedures.

Improved Procedural Communication: Provide regular Q&A sessions and work discussion forums to ensure each employee understands the work steps that must be carried out according to standards.

Method Factor

Implementation of Standard Operating Procedures (SOP): Designing and implementing clearly documented SOPs for all stages of production, especially the sewing process, to create consistency and uniformity of work results (Sadikin, 2023).

Machine Factors

Preventive and Corrective Maintenance: Establish a regular maintenance and inspection schedule for all sewing machines to prevent technical breakdowns and maintain optimal production equipment performance.

Environmental Factors

Improvements related to environmental factors were directed toward strengthening storage management and workplace cleanliness as integral components of quality control. The rearrangement of the storage system was designed to ensure that both raw materials and finished products were placed in an orderly and clearly designated layout, allowing easier supervision and reducing unnecessary handling. By organizing storage areas in accordance with industrial storage standards, the risk of material damage, deformation, or unintended contamination during storage and transfer processes can be minimized. A more structured storage arrangement also supports smoother production flow, as materials can be accessed efficiently without compromising their quality.

Alongside improvements in storage layout, the implementation of a systematic cleanliness policy was emphasized to maintain a controlled production environment. Routine cleaning procedures were introduced across workstations, equipment surfaces, and storage areas to prevent the accumulation of dust, oil, and residual materials that could negatively affect product quality. This policy not only helps preserve the physical condition of materials and finished products but also reinforces discipline and quality awareness among employees. Through consistent environmental control and cleanliness practices, the likelihood of contamination and product damage can be significantly reduced, supporting sustained quality improvement outcomes.

Control

This stage focuses on monitoring and controlling the production process to ensure quality remains within predetermined limits, and to prevent regression to the initial condition before improvement (Yadav & Sukhwani, 2016). Based on the results of calculating product defect data in the reusable diaper production process, it was found that the defect rate was still above

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the expected quality standard. Therefore, the company needs to continue continuous improvement efforts to reduce the level of product defects that have occurred (Salvador, 2024). The goal of this stage is to ensure the achievement of quality targets according to Six Sigma standards, namely producing products with a defect rate of less than 5% (S. K. Mittal, 2022). For this reason, the implementation of an effective quality control system is required. Success is greatly influenced by management involvement, employee training, and the implementation of continuous control. (Study et al., 2025)

The fact that the average defect rate went down after the implementation of DMAIC signifies that the improvement initiatives worked in solving some of the most obtrusive sources of variation in the production process. However, the level of sigma achieved indicates that the process has not as yet achieved a strong stability state. However, this improvement is not a final result, but a stage of the initial ability formation, during which procedural coherence and an increased awareness have started their work as the means of the quality performance. Other recent studies in manufacturing have also reported similar trends where initial Six -Sigma interventions drive visible improvements but require additional improvement to sustain control, especially in labour-intensive production settings (Mittal et al., 2023; Iskandar et al., 2025).

Analytically justified is the choice of the concentration of efforts on untidy stitching and tearing defects, since the type of defects is structurally associated with the sewing-intensive operations. Past studies in the sphere of textile and garment manufacturing prove that the errors in seam are often the result of interaction between the operator technique, the machine state, and the material properties, but not the errors of single mistakes. As Nugraha (2026) and Sadikin (2023) observe, informal adjustments of an operator, which are not directly intended to enhance it, can make things more varied when production depends on tacit knowledge heavily. In this regard, the fact that stitching-related defects dominated in this study reflects the significance of process standardisation as a quality stabilising mechanism, instead of the use of inspection or rework.

The human factors are still a crucial component in the continuation of the defects that still happens despite the improving efforts. Training and monitoring helped to be more aware of quality needs; however, previous research studies highlight that knowledge is not enough to ensure the consistent performance. As Henny et al. (2021) show, the work of the operator is more stabilized under the conditions of the introduction of appropriate practices into the work norms and their support by regular monitoring. This is why the reduction in defects was realised without the complete eradication of variation because the pressure of production and variation in the workloads still influence the behaviour of operators in the conditions of the lack of strictly regulated standard-work systems.

Problems of the machines also support this interpretation. The stability of sewing machines has a direct impact on stitch consistency and the integrity of fabric, which makes the stability of equipment one of the primary predictors of product quality. According to Hibarkah et al. (2021) and Putra et al. (2024), reactive maintenance approaches tend to allow the gradual loss of performance, thus, re-introducing defects despite improvement efforts that have already been undertaken. The results of the current research are consistent with these observations and it can be concluded that preventive maintenance must be combined with quality monitoring such that performances deviations in machines are noticed as they occur, before they are converted into defective products.

Defects due to environment and handling are also to be interpreted beyond the surface cleanliness like dirty products. Research by Salih and Salah (2024) suggests that contamination

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can be detrimental of the material flow, presence of discipline in storage and placement of work. Defects are generated in a systematic way when fabrics and semi-finished products are exposed to uncontrolled environments. These defects in the given study show that layout design, material protection, and inventory control are considered as part of the quality management and not as a secondary operational issue.

The viability of the realized improvements is directly connected to the power of the Control phase in the DMAIC system. Recent researches underline that quality improvement is prone to regression in case monitoring systems and the response mechanisms are poor. Conde et al. (2023) and Oprime and Sordan (2023) state that regular use of control charts, regular audits, and defined procedures of corrective measures is critical in ensuring that processes perform at the required level. The fact that the defect rates witnessed in this study are moderate but steady indicates that the DMAIC framework is working, but it needs a greater institutionalisation to prevent quality deterioration in time.

The results demonstrate that the DMAIC method has helped the organisation to determine the prevailing causes of defects and take relevant corrective measures, as well as to demonstrate the boundaries of a single process improvement cycle in the case of process variability that has deep roots. Recent research by Fachrudin et al. (2025), Nur (2024) and Shbool (2025) indicates that the further cycle of improvement is to be narrowed down key parameters of the processes, increase the strength of mistake-proofing and enhance discipline of the standard-work. In this respect, the value of the study is to show that it is possible to initiate quality improvement through a structured approach to transform production performance in a resource-suffering manufacturing environment, and that long-lasting improvement should be viewed as a process of constant refinement, and not as an intervention.

Conclusion

Based on the analysis conducted to improve the quality of reusable diaper products through the application of the Six Sigma approach using the DMAIC method, several key conclusions can be drawn. The study reveals that the production process is affected by four dominant types of defects, namely torn or broken products, untidy stitching, products in dirty condition, and imprecise or slanted product shapes. These defect categories represent critical quality issues that directly influence product functionality, aesthetic value, and consumer satisfaction, indicating that quality challenges occur across multiple stages of the production process.

An evaluation of production performance following the implementation of corrective actions demonstrates a measurable improvement in process quality. The Defects Per Million Opportunities calculation resulted in a value of 28,577, which implies that out of every one million units produced, approximately 28,577 units are still potentially defective. This performance corresponds to a sigma level of 3.41, reflecting progress in defect reduction and process stabilization. However, this level also indicates that the production system has not yet reached optimal capability, suggesting the need for continued refinement and sustained quality improvement efforts.

Further analysis of the root causes highlights that product non conformity is largely driven by a combination of human, procedural, technical, and environmental factors. Limitations in employee training and skill development reduce consistency in production practices, while insufficient understanding of work procedures leads to deviations from the intended workflow. The absence of clearly structured standard operating procedures weakens process standardization, and inadequate machine maintenance contributes to technical variability. Additionally, substandard work environment conditions further exacerbate quality issues by increasing the risk of contamination and material damage.

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In response to these findings, the study formulates a set of improvement strategies designed to support sustainable quality enhancement. These strategies include strengthening human resource capacity through targeted training programs, developing and enforcing systematic standard operating procedures, implementing regular machine maintenance and inspection schedules, and improving workplace organization and environmental conditions. Collectively, these measures are expected to reduce defect occurrence, stabilize production processes, and support long term improvements in product quality and operational efficiency.

Declaration statement

Muhammad Afandi:Conceptualization, Methodology, Writing - Review & Editing, Supervision, Formal analysis. Muhammad Hermansyah: Supervision, Project Administration, and Validation.

Confession

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