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Analysis of the Application of the Six Sigma Method in Quality Control of the Mirror Packaging Process: A Case Study of UMKM Moca More Store

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Abstract

This study evaluates and enhances the quality control process at Moca More Store, a micro, small, and medium enterprise (MSME), through the application of the Six Sigma methodology. Using data from January to September 2024, quality issues were analyzed via Defects Per Million Opportunities (DPMO), sigma level calculation, control charts, Pareto diagrams, and fishbone diagrams. Results indicate considerable process variability, with DPMO values ranging from a peak of 8,833 in July to a low of 5,563 in April, and a maximum sigma level of only 2.77. Inadequate packaging accounted for 78.83% of defects, making it the primary improvement target. Root cause analysis identified human factors, methods, machinery, and raw materials as major contributors to the problem. The improvement and control phases implemented standard operating procedures and real-time monitoring tools to reduce defects and stabilize processes. The study concludes that Six Sigma can effectively pinpoint and address critical quality issues in MSMEs, but long-term improvement requires embedding a quality-oriented culture, maintaining systematic control mechanisms, and integrating continuous feedback.

Keywords: Six Sigma; Quality Control; DPMO; MSME; Control Chart; Root Cause Analysis; Process Improvement

INTRODUCTION

In the rapidly growing digital era, e-commerce platforms have become a primary channel for consumers to conduct transactions. Statistical data reveals that approximately 59.3% of the total internet user population in Indonesia, which reaches 185.3 million people, now utilize e-commerce services to purchase products. This phenomenon reflects the vast and expanding electronic trade landscape in the country, with significant potential to optimize business operational efficiency through innovations in various aspects, including packaging and product shipping (Ridwan et al (2023) and Erpurini et al. (2022))

One of the product segments that has seen increased demand in the market is home décor, which has become more complex and personalized (Gumilang & Purnomo, 2024). Modern decorative mirrors, made from glass and coated with reflective materials such as aluminum or silver, have become popular choices for enhancing home interiors (Simanjuntak et al., 2024). The varied and elegant designs of these mirrors are increasingly favored as they add aesthetic value to a room (Elfanda, 2021).

However, as the demand for decorative products like mirrors rises, inadequate packaging becomes a critical issue. Poor packaging can result in product damage, which not only diminishes the customer experience but also harms the producer's reputation (Andriani et al., 2023). Decorative mirrors, being fragile items, are particularly susceptible to physical damage such as cracks or breakage during shipping. According to research by Gangai & Naik (2015), over 30% of product damage is caused by improper packaging, which can reduce consumer confidence in the brand and jeopardize business continuity.

Although the glass and décor industry holds promising prospects, quality control in packaging remains a significant challenge, especially for Micro, Small, and Medium Enterprises (MSMEs) operating in this sector (Aprila et al., 2023). Many MSMEs, such as Moca More Store, face issues related to choosing inappropriate packaging materials, lack of worker training in proper packaging techniques, and the absence of clear Standard Operating Procedures (SOPs) (Ayu et al., 2023). As a result, the quality of products received by consumers often falls short of expectations, and many products are damaged during the shipping process. According to interviews conducted with the owner of Moca More Store, this issue has led to a high number of returns due to products breaking during transit, causing financial losses and damaging the business's reputation.

To address these challenges, efficient and effective packaging becomes a key factor in reducing product damage and enhancing customer satisfaction (Sari & Nugraha, 2025). Therefore, it is essential for Moca More Store to implement innovations in its packaging strategy that not only prioritize physical protection of the products but also optimize shipping costs and delivery times. This research aims to examine how the Six Sigma methodology with the DMAIC approach (Define, Measure, Analyze, Improve, and Control) can help Moca More Store improve its packaging processes for decorative mirrors to reduce the risk of damage and enhance shipping service quality (B. A. D. Putri et al., 2019).

Several previous studies have shown that the Six Sigma approach, which focuses on reducing variability and defects in processes, can be applied to improve packaging quality. Research by Ramadhani et al (2023) indicated that quality control in packaging using Six Sigma can improve efficiency and maintain product quality. Additionally, studies by Ditahardiyani et al. (2009) and Hassan et al (2016) suggest that implementing Six Sigma in packaging processes has been effective in identifying and reducing packaging defects, leading to a reduction in product damage rates.

Looking at data from Moca More Store, which experienced product damage rates exceeding the owner's set standard (2%) from January to September 2024, applying Six Sigma through the DMAIC approach is believed to provide practical solutions to reduce product damage and improve customer experience. Therefore, this study has the potential to significantly contribute to enhancing packaging quality in the glass industry, particularly for MSMEs operating in the e-commerce sector, while enriching operational management research in the digital age.

This research offers a novel approach to addressing packaging challenges for glass products, specifically decorative mirrors, in the context of e-commerce, with a focus on applying the Six Sigma methodology through the DMAIC (Define, Measure, Analyze, Improve, Control) approach. While Six Sigma has been implemented across various industrial sectors, this research highlights its application in the home décor industry, which has been relatively underexplored, especially within MSMEs facing specific challenges related to packaging fragile products like decorative mirrors. The novelty of this study lies in combining quality control through Six Sigma with innovations in the packaging process, aiming to enhance product protection during shipping and reduce damage rates. Additionally, this research contributes to the development of a more systematic standard operating procedure (SOP) and worker training to improve packaging quality at the MSME level.

The primary objective of this research is to identify and analyze the packaging issues faced by Moca More Store in the shipping of decorative mirror products and to apply the Six Sigma methodology to improve the packaging quality. More specifically, this study aims to analyze the factors contributing to product damage, apply Six Sigma using the DMAIC approach to enhance packaging quality, and develop clear and effective SOPs for product packaging. Furthermore, this research seeks to measure the impact of packaging improvements on reducing product damage rates and increasing customer satisfaction. As a result, this study is expected to provide practical solutions for MSMEs to enhance their packaging quality, while contributing significantly to the development of operational management in the home décor industry, particularly within the e-commerce sector.

METHODS

This study employs a qualitative approach, designed to gain a deep understanding of the phenomena occurring at Moca More Store, an MSME engaged in decorative furniture located at JL.GA Manulang Perumahan Bentang Padalarang Regency. This approach was selected due to its ability to provide comprehensive insights into issues that cannot be measured through numbers or statistics, focusing instead on the interactions and subjective experiences within the operational processes of the MSME. As stated by Erpurini et al. (2022) and Yentifa et al (2023), the qualitative method focuses on understanding phenomena through the perspectives of individuals. In this context, the perspectives of the store owner and employees will provide valuable insights into the challenges of packaging and shipping products.

According to Sugiyono (2024), qualitative research uses a naturalistic approach that allows the researcher to explore phenomena in their real-life context, without significant interference. In this study, data will be collected using several techniques, including direct observation of the packaging and shipping processes, as well as in-depth interviews with key stakeholders involved in operational activities, such as the store owner, employees, and even customers who have experienced issues with damaged products (Nugraha et al., 2024). These interviews will aim to explore the underlying causes of packaging-related product damage and identify practical solutions based on the participants' experiences and perceptions (Andriani (2023) and Leonandri & Erpurini (2025))

Additionally, document analysis will be conducted to further understand the packaging procedures in place, such as operational manuals or historical data on product damage rates. This approach seeks to provide a clearer and more comprehensive picture of the factors contributing to product damage at Moca More Store, while offering solutions derived from descriptive analysis of the observed phenomena. The main focus of this research is to identify the causes of product damage during packaging and shipping and propose improvements based on the findings. The research will be conducted from January 2024 to September 2024, providing sufficient time to gather valid data and formulate actionable recommendations for the MSME to improve their packaging processes.

RESULTS

Based on the production volume and number of defective products obtained from field observations at Moca More Store during the period of January to September 2024, the following presents the production data and defective products recorded from January to September 2024.

Table 1. Defective Product Data

Month	Produk cacat						
	Initial Production (Units)	Cracks (Units)	Miscuts (Units)	Broken (Units)	Returned Products (Units)	Total Defective Products (Units)	(%)
January	4000	10	7	10	63	90	2.3%
February	3500	8	9	15	55	87	2.5%
March	3000	8	10	7	70	95	3.2%
April	4000	10	6	9	64	89	2.2%
May	3200	7	10	8	75	100	3.1%
June	3000	9	3	3	84	99	3.3%
July	3000	5	3	5	93	106	3.5%
August	4000	5	7	2	90	104	2.6%
September	3900	5	5	2	106	118	3.0%
Total	31600	67	60	61	700	888	25.7%
Averages	3511	7	7	7	78	99	2.9%

Based on the data presented in Table 1, the highest number of defects during the January–September 2024 period was attributed to returned products due to breakage during delivery, totaling 700 units. This was followed by cracks with 67 units, miscuts with 60 units, and breakage due to production errors with 61 units. These findings highlight that the packaging and handling process during distribution plays a critical role in the overall .

Define Phase

The business process flow of Moca More Store consists of several key stages that illustrate the interaction between units or departments in executing a business operation or service. The process begins with the Customer, who submits a request or order. This request is then handled by the Sales department, responsible for confirming the order and communicating it to the Order Processing team. This stage involves the administrative recording and processing of the order. Subsequently, the order is forwarded to the Inventory department to ensure the availability of the required products. If stock is available, the goods are dispatched by the Shipping department to the customer. The process concludes with the Billing department, which manages invoicing and ensures that payment is completed by the customer. This flow represents a structured, end-to-end business process from customer request to payment completion ensuring coordinated and efficient operations across departments..

Measure Phase

In the Measure phase, the quality level of the business process is evaluated using the Defects Per Million Opportunities (DPMO) method. This metric provides insight into the number of defects that occur in every one million opportunities, allowing for a standardized assessment of process performance. After determining the DPMO value, it is then converted into a sigma level a statistical representation of how effectively a process operates without producing defects. The higher the sigma level, the fewer the defects, indicating a more capable and controlled process. This conversion is typically conducted using built-in functions in Microsoft Excel, enabling straightforward and consistent analysis. By quantifying both the defect rate and sigma level, organizations can better understand the current state of their processes and identify specific areas for quality improvement.

Table 2. DPMO Calculation

Month	Total Production (Units)	Total Defective Products (Units)	CTQ	DPMO	Sigma Level
January	4000	90	4	5625	2.77
February	3500	87	4	6214	2.74
March	3000	95	4	7917	2.66
April	4000	89	4	5563	2.77
May	3200	100	4	7813	2.66
June	3000	99	4	8250	2.64
July	3000	106	4	8833	2.62
August	4000	104	4	6500	2.72
September	3900	118	4	7564	2.67
Total	31600	888	-	-	-
Average	3511	99	-	-	-

Sources: Data Processed, 2025

To measure process quality at Moca More Store, a DPMO (Defects Per Million Opportunities) and sigma level analysis was conducted for the period of January to September 2024. The analysis considered the number of units produced, the number of defective products, and four Critical to Quality (CTQ) characteristics per unit. The results showed monthly DPMO values ranging from 5,563 in April to 8,833 in July. The corresponding sigma levels ranged between 2.62 and 2.77, indicating a moderate level of process capability. Notably, the lowest DPMO and highest sigma level (2.77) were achieved in January and April, suggesting better process control during those months. In contrast, July recorded the highest DPMO, reflecting the greatest number of defects per opportunity, and correspondingly the lowest sigma level. The average monthly production was 3,511 units with approximately 99 defective products, highlighting the need for further quality improvement efforts. This analysis serves as a key performance indicator to track quality trends over time and identify months where corrective actions may be necessary.

Control Chart

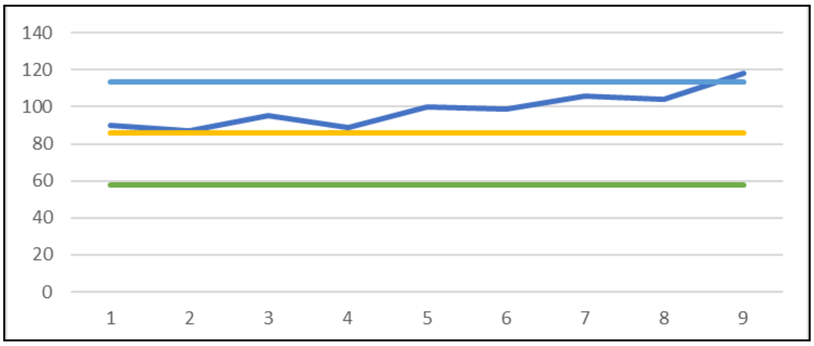

Figure 1. Control Chart

Sources: Data Processed, 2025

Based on the control chart for defective products during the period of January to September 2024, several data points are observed to fall outside the upper control limit (UCL). This indicates that the packaging process is not entirely under control and may be a major contributing factor to the increased number of defective products. The presence of these out-of-control points suggests instability in the packaging process, highlighting the need for significant improvements to ensure consistent quality. Furthermore, attention should not only be given to the external packaging, but also to maintaining the integrity of the product itself. This is crucial to ensure that products reach consumers in a safe condition and in accordance with established quality standards.

Analyze Phase

Pareto Diagram

The Pareto diagram is a useful tool to identify the most frequent types of defects that affect the quality of the packaging process. The data used in this analysis represents defective mirror products recorded during the period of January to September 2024.

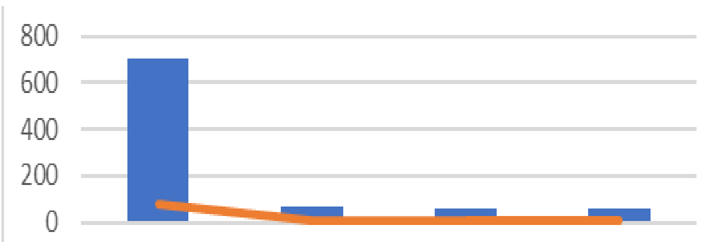

Figure 2. Pareto Diagram

Sources: Data Processed, 2025

Based on the Pareto diagram, the most dominant type of defect is returned goods due to non-compliant packaging, with a total of 700 units accounting for 78.83% of all recorded defects. This indicates that packaging issues are the primary contributor to product nonconformities. On the other hand, the least frequent defect type is cutting errors, with only 60 units or 6.76% of the total. This comparison reflects the Pareto principle (80/20 rule), suggesting that the majority of quality problems stem from a small number of defect types.

Fishbone Diagram

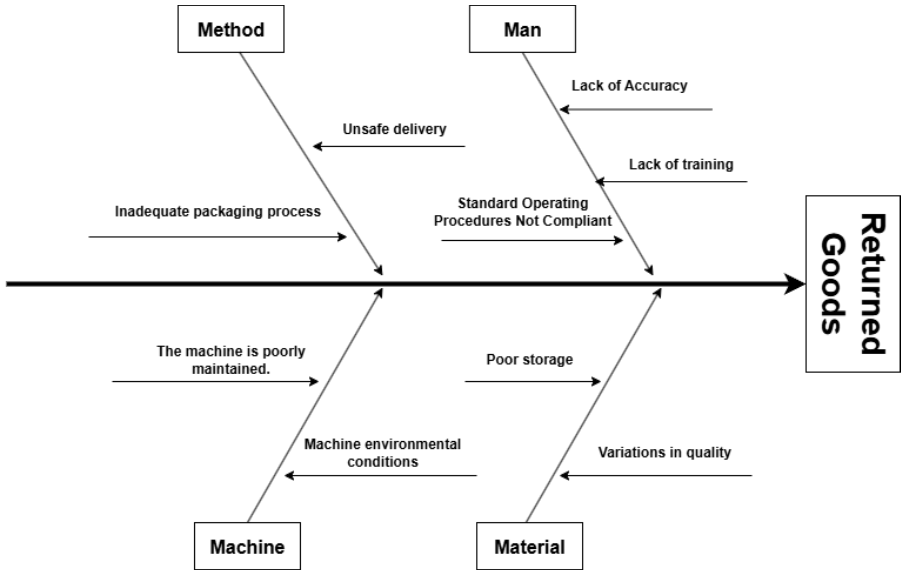

Figure 3. Fishbone Diagram

Sources: Data processing, 2025

The fishbone diagram presented is used to identify the root causes of product defects occurring during the production process. This analysis focuses on four main categories: Method, Manpower, Machine, and Materials. From the Method aspect, the primary causes include poor implementation of Standard Operating Procedures (SOPs) and the absence of a final evaluation standard to ensure product quality before delivery to customers. Under the Manpower category, issues arise from operator inaccuracy and a lack of training or proper communication regarding work procedures, leading to task execution errors.

The Machine factor contributes to product defects mainly due to equipment that does not meet standard requirements and is not inspected before use. Lastly, under Materials, the problems stem from raw materials that do not meet required specifications, including instances where materials were already damaged at the time of use. These four factors collectively affect the final quality of the product. Therefore, improvements are necessary across all these areas to minimize product defects and enhance customer satisfaction.

Improvement Phase

Table 3. Improvement Suggestions

No	Faktor	Masalah	Usulan Perbaikan
1.	Manpower	Lack of attention to detail	1) Create a checklist format for each work process to facilitate verification of completed steps. 2) Provide incentives or bonuses for workers who demonstrate accuracy.
		Non-compliant SOPs	3) Regularly review and update SOPs to ensure their relevance and clarity. 4) Develop visual SOPs in the form of diagrams or images.
		Lack of training	5) Develop structured training programs 6) Conduct evaluations to measure training effectiveness
2.	Method	Unsafe delivery	1) Improve packaging using foam sheets and Styrofoam inserts to reduce damage during transport. 2) Provide shipping insurance.
		Inadequate packaging process	3) Create standardized SOPs for packaging to ensure consistency. 4) Conduct quality testing on packaging.
3.	Machine	Poor machine maintenance	1) Establish a routine machine inspection schedule 2) Train technicians on how to properly maintain and repair equipment.
		Poor machine environment	1) Improve cleanliness in the work area.
4.	Materials	Improve cleanliness in the work area	1) Reorganize storage layout for better accessibility and organization.
		Quality inconsistency	2) Implement quality testing procedures for incoming raw materials to ensure compliance with specifications.

Sources: Data processing, 2025

After the improvement phase has been completed, the next step is the control phase, which aims to ensure that the implemented improvements are carried out consistently and sustainably. The main focus of this phase is to establish an effective monitoring system that can identify potential issues early before they escalate into serious disruptions. A key approach in this stage is the implementation of clear and measurable Standard Operating Procedures (SOPs), along with the use of monitoring tools such as control charts to track process outputs in real time. Additionally, customer feedback systems play a crucial role in the control phase, as they provide direct insights into areas that still require improvement. This ensures that the improvements remain aligned with customer needs and established quality standards.

DISCUSSION

Product quality is one of the key indicators of success in MSME operations, particularly in retail sectors that interact directly with end consumers. This study reveals that Moca More Store faces significant challenges in maintaining consistent product quality, as reflected in the Defects Per Million Opportunities (DPMO) analysis. The fluctuating DPMO values, peaking at 8,833 in July and reaching the lowest point of 5,563 in April, indicate instability in the process that cannot be overlooked. Such variability highlights weaknesses in process control systems and the gap between quality planning and execution. From a Total Quality Management (TQM) perspective, this variability reflects a lack of process capability to consistently meet defined specifications.

Furthermore, the highest observed sigma level of only 2.77 reinforces the argument that the production process remains underperforming when viewed through Six Sigma standards. Theoretically, a sigma level below 3 implies a defect rate exceeding 66,000 units per million opportunities an unacceptable level in industries with high-quality expectations. While MSMEs may not be expected to reach industrial manufacturing standards, these findings signal the urgent need for a structured quality improvement approach. Low sigma values also suggest high quality costs, particularly in internal and external failure categories, which directly impact the enterprise's profitability.

The implementation of control charts in this study effectively identified points that exceeded the Upper Control Limit (UCL), statistically signaling that these variations were not due to random chance but rather to assignable causes requiring deeper investigation

(Riptanti et al (2023) and Nugraha et al (2024)). This indicates an out-of-control process, particularly in the packaging stage the final control phase before products are delivered to customers. Such deviations can seriously affect customer perception and long-term loyalty (A. W. Putri et al., 2022). In the Six Sigma framework, the inability to identify special causes of variation is known as "process drift," a critical target in quality improvement projects (Sari & Nugraha, 2025).

Supporting analysis from the Pareto diagram further emphasizes the urgency of focusing on packaging improvements. With 78.83% of defects originating from inadequate packaging, this area should be prioritized in the quality enhancement strategy. The findings are aligned with the 80/20 Pareto principle, which states that most effects stem from a small number of causes. In this context, a single major issue contributes dominantly to overall defects. Therefore, allocating improvement resources toward refining the packaging process could significantly improve total product quality (Li, 2024). This also highlights the need for strict final inspections and adherence to standardized procedures before distribution.

To identify root causes systematically, the fishbone diagram was employed and revealed four dominant contributing factors: human (man), method, machine, and material. Human-related issues such as insufficient training and operator negligence demonstrate a lack of workforce readiness to uphold quality standards. Meanwhile, problems in method, such as inconsistent implementation of SOPs and the absence of final evaluations, highlight gaps between documented standards and actual field practices. Machine-related issues and substandard raw materials further exacerbate the situation, indicating weak supplier control and poor equipment maintenance. These factors are interrelated and together form a cycle of underlying problems that negatively affect product quality.

Following the improvement phase, the control phase becomes critical to ensuring the long-term sustainability of enhancements. In Six Sigma methodology, this is where the success of a quality improvement project is truly tested in an operational context. The implementation of updated SOPs, regular employee training, real-time monitoring tools like control charts, and structured customer feedback systems are essential components of an effective control system. Beyond monitoring, the control phase must serve as an early warning system to detect signs of quality decline before they become systemic. For MSMEs, embedding a data-driven quality culture and responding swiftly to customer input are strategic steps toward differentiation in a competitive market landscape.

The implications of these findings are far-reaching not only for Moca More Store but also for other MSMEs aiming to adopt Six Sigma practices. The study demonstrates that despite limited scale, MSMEs face complex quality challenges that require systematic, data-driven solutions. The combination of quantitative and qualitative tools used—DPMO, sigma level, control charts, Pareto, and fishbone offers a comprehensive understanding of quality issues. Therefore, successful quality improvement in MSMEs depends not only on technical capability but also on managerial commitment to integrating quality into the core of business operations.

CONCLUSION

This study demonstrates that the application of the Six Sigma approach at Moca More Store, a micro, small, and medium enterprise (MSME), can effectively identify and analyze the primary sources of quality issues. Based on the calculation of Defects Per Million Opportunities (DPMO) and sigma levels, the results indicate high variability in the business process, with the highest sigma level reaching only 2.77. This highlights a considerable potential for quality improvement. Analysis using control charts, Pareto diagrams, and fishbone diagrams revealed that packaging-related defects, driven by issues in methods, human factors, machines, and raw materials, are the predominant source of product failures. The improvement and control phases within the Six Sigma framework have provided a structured path to reduce defects and establish a more sustainable quality control system.

Despite offering valuable insights, this study is subject to several limitations. First, the analysis only covers a nine-month period (January–September 2024), which may not fully reflect annual or seasonal fluctuations in demand and operations. Second, the study does not incorporate a comprehensive cost-benefit analysis of implementing Six Sigma, which is a key factor for MSMEs with limited resources. Moreover, external variables such as market conditions, pricing dynamics, and consumer behavior were not included in the analysis, despite their indirect impact on product quality.

Future research should extend the observation period to cover a full year or more to capture long-term trends and seasonal variations. Incorporating economic analysis will also be essential to assess the financial viability of Six Sigma implementation in MSMEs. Additionally, future studies could explore integrating Six Sigma with other quality management approaches such as Lean or Total Quality Management (TQM) for more holistic process improvements. Lastly, it is crucial for MSMEs to embed a culture of quality across their operations by investing in continuous training, engaging customer feedback systems, and utilizing digital tools for real-time quality monitoring.

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