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Analysis of Production Defect Quality in Mug Products Using Six Sigma, FMEA, & Kaizen Methods at Markaz Souvenir Surabaya

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Abstract

Markaz Souvenir is a business that produces various types of souvenirs, including ceramic mugs. However, there is a significant production failure problem. This study aims to identify and minimize product defects at Markaz Souvenir using the Six Sigma method and Failure Modes and Effects Analysis (FMEA) analysis. The results showed that the defect data was normally distributed with a failure rate of 482 units, a Defect Per Million Opportunities (DPMO) value of 22790, and a sigma level of 3.5, which is still at the Indonesian industry average. FMEA analysis identified three main types of defects: surface scuffing, logo fading, and surface unevenness, with the main causes being suboptimal machine conditions and low-quality raw materials. The highest Risk Priority Number (RPN) value was 112 for the logo fading defect. Suggested improvements include regular machine inspections, the use of better quality raw materials, and increased lighting intensity in the production area. In addition, the application of the Kaizen method with 5-S is proposed for continuous improvement. The 5-S steps involve organizing work areas, cleanliness, and consistent application of standards to improve product quality and production efficiency.

Keywords
Ceramic Mug, FMEA, Kaizen, Production Defects, Six Sigma

1. Introduction
The souvenir industry in Indonesia has experienced rapid growth alongside the increasing number of domestic and international tourists (Mayuzumi 2022). This surge in tourism has significantly boosted the demand for souvenirs, with ceramic mugs being one of the most popular items (Hitchcock and Teague 2019). Ceramic mugs are not only functional but also serve as promotional tools, reflecting local culture and identity (Ao et al. 2024). The customization potential of ceramic mugs, with designs that reflect unique regional features or specific events, has contributed to their widespread appeal (Choudhari et al. 2024). Furthermore, these mugs are effective promotional media due to their frequent use in daily life, providing high exposure for businesses (Hervet and Guitart 2022).

Markaz Souvenir, an SME specializing in souvenirs such as ceramic mugs, faces challenges in ensuring consistent product quality. As a business dependent on customer trust and reputation, maintaining high-quality products is crucial for sustainability (Le 2023). However, the lack of a formal quality control system has led to defects like scratches, faded logos, and uneven surfaces, which negatively impact customer satisfaction and the company's reputation (Bag et al. 2023). These defects result in complaints, product returns, and ultimately affect the business's overall performance.

To address these issues, Markaz Souvenir has decided to implement Six Sigma methodologies. Six Sigma, a data-driven approach aimed at minimizing defects by identifying and eliminating the causes of variability in production processes, is recognized for improving product quality and operational efficiency (Clancy et al. 2023). Additionally, Markaz Souvenir has adopted Failure Modes and Effects Analysis (FMEA) to proactively identify potential failures and eliminate them before reaching the customer. To ensure continuous improvement, the company has also embraced Kaizen, a philosophy that encourages constant innovation and incremental quality improvements (Okoro 2024). By applying these three methods, the company aims to identify the root causes of defects and enhance the overall quality of the ceramic mugs produced.

1.1 Objectives

This study aims to analyze and minimize the factors causing defects in ceramic mug products at Markaz Souvenir using the Six Sigma method. The main focus of this research is to identify the types of defects that frequently occur, such as surface scratches, faded logos, and uneven surfaces, as well as optimize the production process to reduce the number of defective products. This approach is expected to improve overall production efficiency and product quality. The contribution of this research is to provide deeper insights into the application of Six Sigma, FMEA, and Kaizen in the SME sector, particularly in the context of ceramic product manufacturing. By using structured analytical methods, this study aims to provide practical solutions for production issues faced by Markaz Souvenir, as well as serve as a guide for other SMEs in improving product quality and operational efficiency.

2. Literature Review

This study reviews the theoretical and practical aspects of Six Sigma, FMEA, Kaizen, and ceramic mug production as key methodologies for improving quality, optimizing processes, and fostering innovation. It includes recent research (2020 onward) for relevance, supplemented by earlier studies to address research gaps, providing a comprehensive understanding of their industrial applications.

2.1 Six Sigma

Six Sigma improves quality by minimizing defects and reducing process variability. It uses the DMAIC framework (Define, Measure, Analyze, Improve, Control) to systematically eliminate root causes of defects (Qayyum et al. 2021). With a target defect rate of 3.4 per million opportunities, Six Sigma enhances efficiency, cuts costs, and boosts competitiveness (Madhani 2020).

2.2 Failure Mode Effect Analysis (FMEA)

FMEA identifies potential failures in processes, products, or designs and evaluates their impact. By addressing critical risks proactively, it enhances reliability, customer satisfaction, and operational efficiency. FMEA minimizes disruptions and ensures smooth product functionality, safeguarding brand reputation (Erdil and Erbiyik 2023).

2.3 Kaizen

Kaizen emphasizes continuous, incremental improvements involving all organizational levels (Okpala et al. 2024). Using tools like 5S and 5W & 1H, it identifies inefficiencies and drives process enhancements. This philosophy enables adaptability, efficiency, and consistent delivery of high-quality products (Kolasani 2023)

2.4 Ceramic Mug

Ceramic mugs are crafted from clay using techniques like pinching, molding, or spinning, followed by high-temperature firing for durability. Pinched designs embody the wabi-sabi aesthetic, valuing imperfection and authenticity. With customizable cultural designs, ceramic mugs combine artistic and functional appeal, offering strong market potential (Nawar et al. 2024).

3. Methods
This study was conducted at Markaz Souvenir, located in Medokan Ayu, Surabaya, to analyze defective mug products using data from a 50-day production period starting in January 2024. The research was carried out from April to May 2024 and involved field observations and data assessments to evaluate production performance and identify defect trends. The analysis focused on independent variables, including types of defects such as scratched surfaces, faded logos, and uneven surfaces, and their impact on the dependent variable, the total number of defective mugs produced. Understanding these variables was essential for identifying root causes of production issues.

Data collection employed both primary and secondary methods. Primary data were gathered through interviews and direct observations at Markaz Souvenir to capture real-time production insights. Secondary data were sourced from the company's historical archives, detailing production and defect records over the 50-day period. This comprehensive dataset enabled the identification of defect patterns and informed strategies for process improvement.

4. Data Collection
This study gathered primary data through interviews and direct observations at Markaz Souvenir, Medokan Ayu Surabaya. Secondary data were collected from historical records and reports at Markaz Souvenir, focusing on mug production and defective product data over a 50-day period, approximately 7 weeks (Table 1).

Table 1. Observation Data

The lot		Defect Type		
Observation (n) (unit)	d (defect) (unit)	Surface Abrasions	Faded Logo	Uneven Surface
150	16	10	3	3
150	17	7	5	5
150	9	3	5	1
150	7	5	1	1
150	7	1	5	1
150	11	3	5	3
150	11	3	5	3
150	8	5	0	3
150	9	7	0	2
150	13	9	2	2
150	7	4	2	1
150	10	5	2	3
150	9	6	1	2
150	9	6	1	2
150	10	5	2	3
150	9	6	0	3
150	10	8	2	0
150	9	7	1	1
150	13	9	1	3
150	17	14	1	2
150	8	6	1	1
150	10	8	1	1
150	15	15	0	0
150	14	13	0	1
150	10	9	1	0
150	9	8	1	0
150	9	4	4	1
150	8	5	0	3
150	9	5	1	3
150	8	4	2	2

The lot		Defect Type		
Observation (n) (unit)	d (defect) (unit)	Surface Abrasions	Faded Logo	Uneven Surface
150	10	4	3	3
150	8	7	1	0
150	9	5	3	1
150	11	9	2	0
150	11	10	0	1
150	7	4	2	1
150	14	10	0	4
150	8	5	1	2
150	9	8	0	1
150	14	12	2	0
150	15	10	2	3
150	10	9	0	1
150	10	8	0	2
150	10	8	1	1
150	8	4	2	2
150	8	6	2	0
150	9	4	3	2
150	9	5	1	3
150	18	13	4	1
150	10	5	2	3
7500	519	346	86	87

The following is a flow chart that explains the problem-solving framework used in this research (Figure 1):

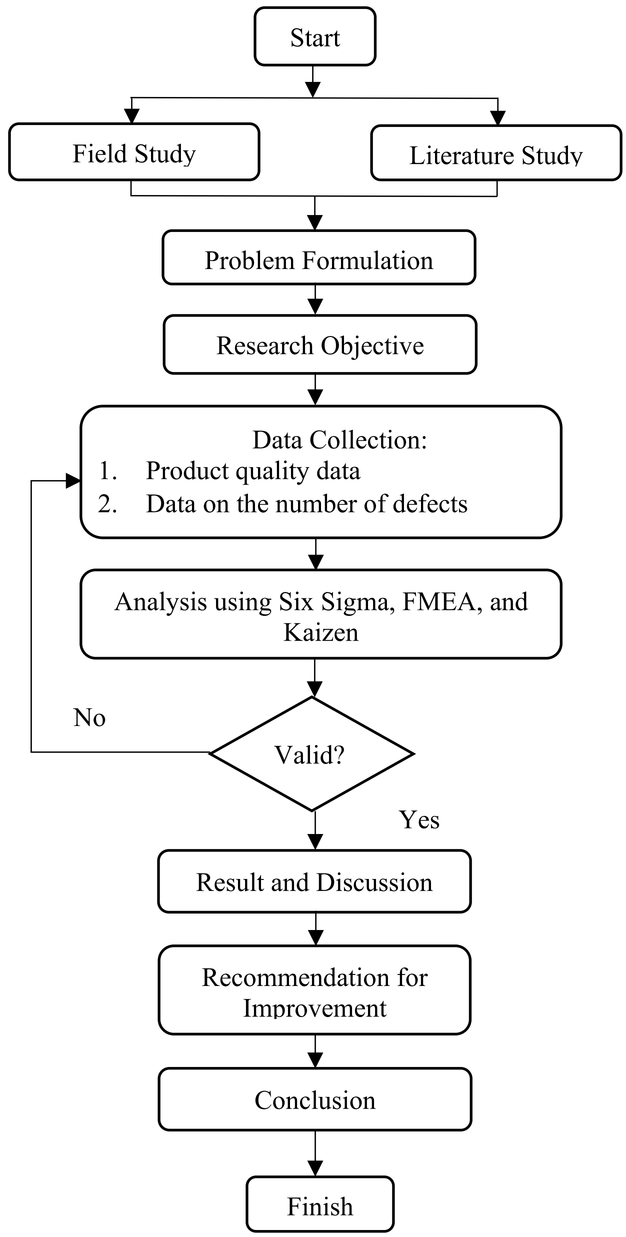

Figure 1. Flowchart

5. Results and Discussion

This chapter presents the results and discussion of the study, focusing on the analysis of mug production quality at Markaz Souvenir Surabaya using the Six Sigma, FMEA, and Kaizen methods. The discussion aims to provide a comprehensive of production quality and strategic measures to reduce defects and enhance process efficiency.

5.1 Product Analysis Using the Six Sigma Method

The Six Sigma quality improvement includes processes namely Define, Measure, Analyze, Improve, and Control (DMAIC).

5.1.1 Define.

1. Project Statement
a. Business Case
Markaz Souvenir, a small enterprise specializing in souvenirs such as mugs, umbrellas, tumblers, and keychains, faces

a high defect rate in its mug production. To improve product quality, this study focuses on key variables like diameter (cm) and attributes such as surfaces abrasions, faded logos, and uneven surfaces.

b. Problem Definition
Markaz Souvenir struggles to maintain high-quality standards in mug production, with common defects including surfaces abrasions, faded logos, and uneven surfaces. These issues lead to customer dissatisfaction and financial losses. Using the Six Sigma approach, this study aims to identify root causes and implement solutions to reduce defects and improve quality.

c. Project Scope
The study focuses on defective mug products at Markaz Souvenir.

d. Goal Statement
The goal is to optimize mug quality by reducing or eliminating defects such as surfaces abrasions, faded logos, and uneven finishes. The application of Six Sigma, Kaizen, and PDCA will help address these issues, enhance customer satisfaction, and reduce losses.

e. Project Timeline
The research will be conducted from April to May 2024.
2. SIPOC (Supplier, Input, Process, Output, Customer) (Table 2)

Table 2. SIPOC

<table>
<tr><th>S (Supplier)</th><th>I (Inputs)</th><th>P (Process)</th><th>O (Outputs)</th><th>C (Customer)</th></tr>
<tr><td rowspan="5">Raw Material Supplier for Mugs</td><td>Half-finished Mugs from Suppliers</td><td>Design Creation</td><td rowspan="5">Mug Products</td><td rowspan="2">Direct Customers</td></tr>
<tr><td>Logo Specification Data for Mugs</td><td>Design Print-out</td></tr>
<tr><td rowspan="3">Workforce and Human Resources</td><td>Logo Cutting</td><td rowspan="3">Distributors</td></tr>
<tr><td>Heating</td></tr>
<tr><td>Cooling</td></tr>
</table>

The following is a description of the SIPOC (Supplier, Inputs, Process, Outputs, Customer) diagram for the production process at Markaz Souvenir, which outlines the key elements involved in the manufacturing of branded mugs. This framework helps to clarify the flow of materials, resources, and activities necessary to ensure the production of high-quality products. The Supplier refers to the entities that provide the raw materials or resources required to start the production process. In this case, the supplier for Markaz Souvenir provides semi-finished mugs, which will undergo further processing and refinement to become the final product. The supplier also provides the necessary materials for the logos to be printed on the mugs, ensuring that the input materials meet the required quality standards. Human resources, such as machine operators and other staff, are also crucial in ensuring the smooth operation of the production process.

Inputs are the materials, information, and resources required for the production process. For Markaz Souvenir, the main input consists of semi-finished mugs supplied by the supplier, which are processed into finished products. Additionally, the specifications for the logos, including their design, size, and quality standards, are necessary for printing. Human resources are also vital to ensure the correct operation of machines and successful production processes. Process involves the steps taken to convert inputs into finished products, including design creation, printing, logo cutting, heating, and cooling. The Outputs of the process are the final mug products, which are now printed with logos and ready for sale. Finally, the Customers include direct consumers who purchase the mugs for personal use and distributors who sell the products to end consumers at retail levels.

5.1.2 Measure
1. Critical to Quality (CTQ)
In determining Critical to Quality (CTQ) for mugs, the researcher identified three common types of defects during production: surface abrasionss, faded logos, and uneven surfaces. The surface abrasions refers to fine scratches on the mug, often caused by friction during the logo application process. Faded logos occur when the printed logo on the

mug loses its color, typically due to improper logo attachment or inadequate cooling. Uneven surfaces are defects where parts of the mug break, rendering it unsellable, leading to potential losses for Markaz Souvenir. This can be avoided with careful storage and handling during both storage and distribution (Table 3).

Table 3. Critical to Quality Table

No	Defect Type	Quantity (unit)	Percentage of Defects (%)	Cumulative Percentage (%)
1	Surface Abrasions	352	63,88%	63,88%
2	Faded Logo	101	18,33%	82,21%
3	Uneven Surface	98	17,79%	100,00%

Description:

- Surface abrasions occur due to employees not being careful during the process of storing the mugs into the packaging.
- Logo fading may occur due to errors in the printing process in the printing press and during attachment to the mug surface.
- Uneven surfaces are caused by employees who are not careful during the logo attachment process.

2. Normality Test (Kolmogorov Smirnov)

The Kolmogorov-Smirnov normality test was conducted to assess whether the data follows a normal distribution. The hypothesis testing procedure involved several steps. First, the null hypothesis (H0) stated that the data is normally distributed, while the alternative hypothesis (H1) suggested that the data is not normally distributed. The level of significance (α) was set at 0.05. Next, the critical region was determined, with $D \leq D\alpha$, where Dα for a sample size of 47 (n = 47) was 0.1984. The maximum difference (Dmax) calculated was 0.1959, which was then compared with the table value of D47 = 0.197. Since the maximum difference (0.1959) was smaller than the critical value (0.197), the decision was made to accept the null hypothesis (H0) and reject the alternative hypothesis (Ha). This result indicates that the defect data from the observations follows a normal distribution.

3. P-Chart

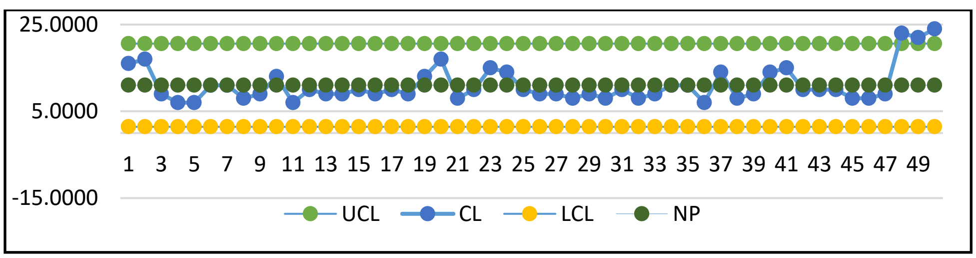

Figure 2. NP Control Map

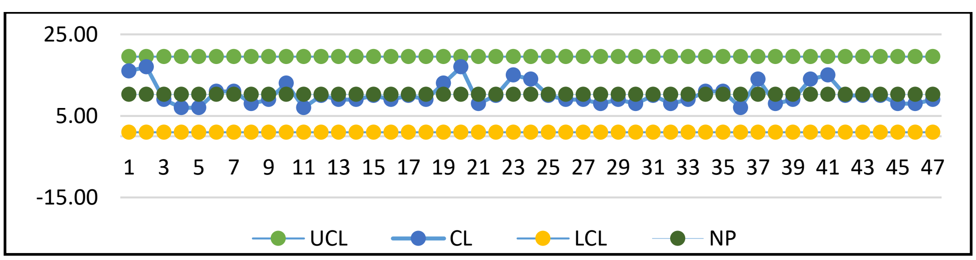

Figure 3. NP Control Map Revision

Figure 2 shows the NP control chart used to display the number of defects in the products, with a constant sample size for each observation. The defects were calculated by summing the mugs with surface abrasionss, faded logos, and uneven surfaces. The Upper Control Limit (UCL) was found to be 20.606, and the Lower Control Limit (LCL) was 1.434. From the chart, it was observed that data points for sample 48, 49, and 50 were out of control, with defect values of 23, 22, and 24, respectively, exceeding the UCL. Therefore, these points were excluded from the analysis, and a revised NP control chart was created, as shown in Figure 3, with new UCL and LCL values of 19.53 and 0.98, respectively. The revised chart no longer includes out-of-control data, as the problematic points have been removed.

4. Calculating DPMO and Six Sigma (Table 4)

Table 4. DPU, TOP, DPO, DPMO, and Six Sigma Calculation Data

Observasi	Total Produksi (u)	Total Cacat (d)	CTQ	DPU	TOP	DPO	DPMO	*Six Sigma*
1	150	16	3	0,1067	450	0,0356	35555,56	3,3048
2	150	17	3	0,1133	450	0,0378	37777,78	3,2771
3	150	9	3	0,06	450	0,02	20000	3,5537
4	150	7	3	0,0467	450	0,0156	15555,56	3,6556
5	150	7	3	0,0467	450	0,0156	15555,56	3,6556
6	150	11	3	0,0733	450	0,0244	24444,44	3,4696
7	150	11	3	0,0733	450	0,0244	24444,44	3,4696
8	150	8	3	0,0533	450	0,0178	17777,78	3,602
9	150	9	3	0,06	450	0,02	20000	3,5537
10	150	13	3	0,0867	450	0,0289	28888,89	3,3974
11	150	7	3	0,0467	450	0,0156	15555,56	3,6556
12	150	10	3	0,0667	450	0,0222	22222,22	3,5099
13	150	9	3	0,06	450	0,02	20000	3,5537
14	150	9	3	0,06	450	0,02	20000	3,5537
15	150	10	3	0,0667	450	0,0222	22222,22	3,5099
16	150	9	3	0,06	450	0,02	20000	3,5537
17	150	10	3	0,0667	450	0,0222	22222,22	3,5099
18	150	9	3	0,06	450	0,02	20000	3,5537
19	150	13	3	0,0867	450	0,0289	28888,89	3,3974
20	150	17	3	0,1133	450	0,0378	37777,78	3,2771
21	150	8	3	0,0533	450	0,0178	17777,78	3,602
22	150	10	3	0,0667	450	0,0222	22222,22	3,5099
23	150	15	3	0,1	450	0,0333	33333,33	3,3339
24	150	14	3	0,0933	450	0,0311	31111,11	3,3647
25	150	10	3	0,0667	450	0,0222	22222,22	3,5099
26	150	9	3	0,06	450	0,02	20000	3,5537
27	150	9	3	0,06	450	0,02	20000	3,5537
28	150	8	3	0,0533	450	0,0178	17777,78	3,602
29	150	9	3	0,06	450	0,02	20000	3,5537
30	150	8	3	0,0533	450	0,0178	17777,78	3,602
31	150	10	3	0,0667	450	0,0222	22222,22	3,5099
32	150	8	3	0,0533	450	0,0178	17777,78	3,602
33	150	9	3	0,06	450	0,02	20000	3,5537
34	150	11	3	0,0733	450	0,0244	24444,44	3,4696
35	150	11	3	0,0733	450	0,0244	24444,44	3,4696
36	150	7	3	0,0467	450	0,0156	15555,56	3,6556
37	150	14	3	0,0933	450	0,0311	31111,11	3,3647
38	150	8	3	0,0533	450	0,0178	17777,78	3,602
39	150	9	3	0,06	450	0,02	20000	3,5537
40	150	14	3	0,0933	450	0,0311	31111,11	3,3647
41	150	15	3	0,1	450	0,0333	33333,33	3,3339
42	150	10	3	0,0667	450	0,0222	22222,22	3,5099
43	150	10	3	0,0667	450	0,0222	22222,22	3,5099
44	150	10	3	0,0667	450	0,0222	22222,22	3,5099

Observasi	Total Produksi (u)	Total Cacat (d)	CTQ	DPU	TOP	DPO	DPMO	*Six Sigma*
45	150	8	3	0,0533	450	0,0178	17777,78	3,602
46	150	8	3	0,0533	450	0,0178	17777,78	3,602
47	150	9	3	0,06	450	0,02	20000	3,5537
Total	7050	482	3	0,0684	21150	0,0228	22789,6	3,5099

5.1.3 Analyze

The next step is identifying the root causes of defects using a fishbone diagram. Prior to this, the dominant defects are identified through a Pareto diagram based on defect percentage data.

1. Pareto Diagram

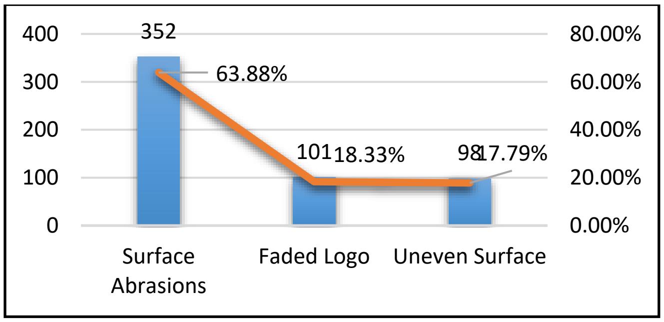

Figure 4. Pareto Diagram

Based on Figure 4 pareto diagram, there are 551 defective mug products, categorized as follows: 352 with surface abrasionss (63.88%), 101 with faded logos (18.33%), and 98 with uneven surfaces (17.79%). The largest defect type, surface abrasionss (63.88%), will be analyzed further using a fishbone diagram to identify its root causes (Figure 5, Figure 6, and Figure 7).

2. Fishbone Diagram

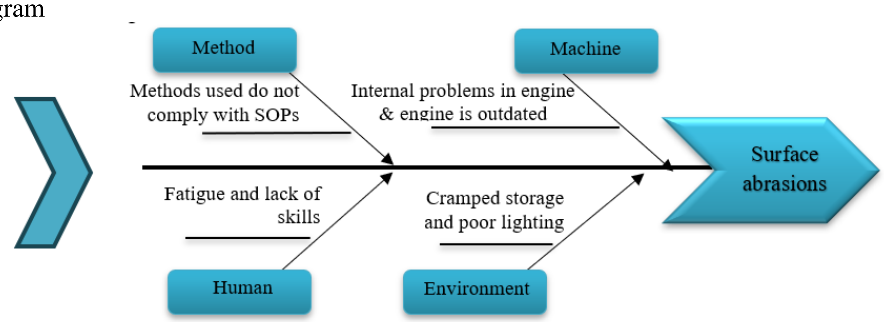

Figure 5. Fishbone Surface Abrasions

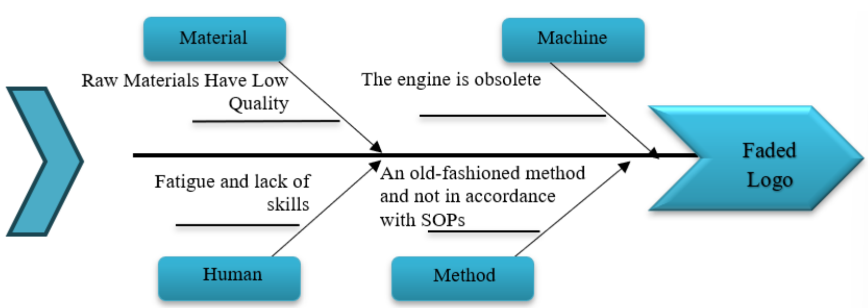

Figure 6. Fishbone Faded Logo

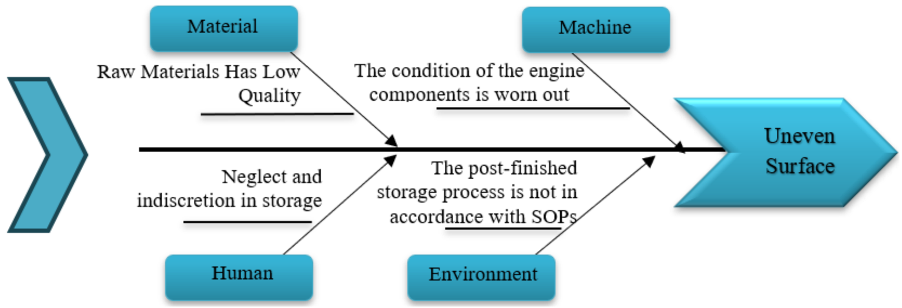

Figure 7. Fishbone Uneven Surface

The fishbone diagrams identify four main factors causing defects: humans, materials, methods, and machines. Surface abrasionss result from worker fatigue, lack of skills, non-compliance with SOPs, poor storage conditions, and outdated machines. Faded logos stem from stress, poor-quality materials like substandard ink, non-standard production techniques, and aging equipment. Uneven surfaces are caused by worker negligence in storage, low-quality materials, inefficient storage conditions, and old machinery. Addressing these issues through training, better materials, SOP adherence, and machine maintenance is crucial.

5.1.4 Improve

This action aims to identify, analyze, and correct facial tissue product defects. With Five M-Checklist and 5W-1H analysis-based measures, Markaz Souvenir is expected to improve quality, reduce defects, and increase customer satisfaction (Table 5).

Table 5. Five M-Checklist

No	Factor	Issues	Improvement Suggestions
1	Man	Operators lack proper training: Many new operators do not fully understand procedures and techniques required for quality products.	Regular training for production operators: Conduct training programs covering all aspects of production and quality control.
		Stress and fatigue: Fatigued or stressed operators are more prone to mistakes.	
2	Machine	Improper calibration: Machines are not correctly calibrated, causing inaccurate production.	Routine maintenance: Schedule regular maintenance and inspection for all production machines.
		Outdated machines	Regular calibration: Perform regular calibration of tools and machines according to industrial standards.
3	Method	Inefficient production procedures: Suboptimal procedures waste time and resources.	Conduct regular audits and reviews of production processes to ensure compliance with SOPs and identify areas for improvement.
		Methods not following SOPs, leading to product defects.	
4	Material	Variable material quality: Raw material quality is inconsistent between batches.	Choose reliable suppliers with a good reputation for providing quality raw materials.
		Poor handling of materials: Improper storage and handling cause material damage.	Conduct quality inspections of raw materials before use in production.
		Materials not meeting specifications.	Store raw materials in appropriate conditions to maintain quality.
5	Environmental	Dirty workspace due to uncleaned debris.	Conduct evaluations and renovations of production areas to ensure a clean and suitable workspace.

5.1.5 Control
The control phase is the final step in improving quality using the Six Sigma method. To enhance product quality through the Six Sigma method, several key actions must be implemented consistently during the control phase:

1. Provide skill training for employees to minimize production errors.
2. Ensure thorough quality checks on raw materials from suppliers.
3. Conduct regular maintenance of machinery to prevent breakdowns.
4. Enforce strict adherence to SOPs among employees.
5. Regularly inspect raw materials and carefully select suppliers for quality assurance.

5.2 FMEA (Failure Mode and Effect Analysis)

Table 6. FMEA (Failure Mode and Effect Analysis)

Mode of Failure	Effect of Failure	S	Causes of Failure	O	Current Controls	D	RPN
Surface Abrasions	Printed logo scratched by other objects	3	Method	6	Provide guidance to recheck during printing	3	54
			Machine	4	Reduce speed and reset the machine	3	36
			Human	4	Conduct briefing or orientation before starting the printing process	2	24
			Environment	5	Increase lighting intensity in the production area	5	75
Faded Logo	Logo and text are not visible or legible	7	Material	4	Replace printing plate with a new one	3	84
			Machine	4	Perform periodic or scheduled machine checks	4	112
			Human	4	Conduct briefing or orientation before starting the printing process	2	56
			Method	5	Provide guidance to recheck during printing	3	105
Uneven Surface	Uneven surface reduces the mug's market value	3	Material	6	Use higher-quality materials	5	90
			Machine	4	Reduce speed and reset the machine	3	36
			Human	4	Provide guidance to recheck during loading the mug into the printing machine	5	60
			Environment	5	Increase lighting intensity in the production area	5	75

Based on the Table 6, alternative solutions for improvement include increasing lighting intensity in the production area for environmental conditions with an RPN value of 75, providing guidance for rechecking during printing for method conditions with an RPN value of 54, and reducing speed and resetting the machine for machine conditions with an RPN value of 36. For human-related conditions with an RPN value of 24, the alternative is conducting briefings or orientations before starting the printing process. For machine conditions with the highest RPN value of 112, periodic or scheduled machine inspections are recommended, while method conditions with an RPN value of 105 require guidance for rechecking during printing. For material conditions with an RPN value of 84, replacing the printing plate with a new one is suggested, and for human conditions with an RPN value of 56, briefings before printing are advised. Lastly, for material conditions with an RPN value of 90, using higher-quality materials is recommended, while environmental conditions with an RPN value of 75 require improved lighting intensity, and human conditions with an RPN value of 60 benefit from guidance when loading mugs into the printing machine.

5.3 Kaizen (Five-Step Plan)

The Five-Step Plan implements the 5S principles (Seiri, Seiton, Seiso, Seiketsu, Shitsuke) to enhance workplace organization, cleanliness, and discipline. This concept emphasizes creating a neat, clean, and orderly work environment, which directly impacts product quality. The 5S principles are applied in this study to address defects such as surface abrasionss, faded logos, and uneven surfaces.

1. Surface abrasions

The Seiri step involves removing unused tools, cleaning equipment, and spare parts from the production area to reduce distractions. During Seiton, tools and spare parts are arranged systematically to ensure easy access and minimize disruption. Seiso focuses on regularly cleaning machines and the work area to avoid residues that could cause scratches. Seiketsu is achieved by establishing cleanliness standards through visual aids and regular reminders. Lastly, Shitsuke ensures that these practices become a habit through regular training and collaborative cleaning activities.

2. Faded Logo

In the Seiri stage, rarely used printing equipment and materials are stored appropriately to declutter the workspace. Seiton involves organizing printing tools and materials in labeled storage for easy access. Seiso emphasizes cleaning printing machines and workspaces regularly to maintain consistent print quality. Seiketsu includes setting cleanliness standards with visual guides and training. Shitsuke ensures the continuous application of 5S practices through employee training and regular cleaning initiatives.

3. Uneven Surface

The Seiri step removes unused raw materials, tools, and spare parts to maintain workflow efficiency. Seiton involves arranging materials and tools in accessible, labeled locations to prevent confusion. Seiso ensures regular cleaning of machines and production areas to maintain quality and safety. Seiketsu focuses on reinforcing these practices through standards and visual reminders. Shitsuke embeds the 5S culture by promoting accountability through consistent training and collaborative activities.

5.4 Discussion Analysis

The analysis of product defects at Markaz Souvenir revealed three main types: scratched surfaces, faded logos, and uneven surfaces. A Pareto chart showed that 63.88% of defects were due to scratched surfaces, followed by 18.33% for faded logos and 17.79% for uneven surfaces. These defects can be addressed using the Six Sigma DMAIC method, FMEA, and Kaizen analysis. DMAIC's Define phase involves identifying the problem, while the Measure phase uses NP charts, revealing a process capability index (Cp) of 0.46, indicating an inefficient process. The Analyze phase identifies root causes, followed by the Improve phase that suggests solutions, such as improving machine settings and operator training. The Control phase ensures these improvements are sustained.

FMEA analysis identifies the most significant risk factors causing defects. For scratched surfaces, environmental factors (RPN 75), method issues (RPN 54), machine settings (RPN 36), and human factors (RPN 24) were addressed. For faded logos, solutions focused on machine maintenance (RPN 112) and material quality (RPN 84). For uneven surfaces, material quality (RPN 90) and machine settings (RPN 36) were prioritized. These solutions focus on improving lighting, machine settings, material quality, and worker training to reduce defects.

The Kaizen approach using 5S principles was implemented to enhance production processes. The Seiri phase involved removing unnecessary items, while Seiton organized tools to minimize errors. Seiso emphasized cleanliness to maintain production quality, and Seiketsu established cleanliness standards through visual guides and training. Shitsuke ensured the continuous application of these practices through regular reviews and teamwork. These steps aim to improve efficiency, prevent defects, and maintain high-quality standards in production.

5.4.1 Recommendations for Improvement

To improve product quality, short-term efforts should focus on employee training through workshops and practical simulations to reduce human errors, along with stricter quality control for incoming materials like logo ink and semi-finished mugs using standardized checklists. Storage conditions can be optimized with anti-abrasion racks to prevent scratches, while production workflows can be streamlined using Lean Manufacturing principles. Medium-term solutions include regular bi-weekly machine maintenance, recalibration, and replacing worn components to ensure consistent logo application. Encouraging Kaizen initiatives and implementing 5S principles will promote an organized, clean, and efficient workspace. Failure Mode and Effects Analysis (FMEA) should prioritize machine maintenance and better material sourcing to address critical defect risks. To ensure success, Key Performance Indicators (KPIs) like defect rates and machine downtime should be monitored, with monthly evaluations to sustain improvements and enhance overall production efficiency.

6. Conclusion

In conclusion, the Six Sigma analysis at Markaz Souvenir revealed that the defect data followed a normal distribution, with a DPMO of 22,790 and a sigma level of 3.5, indicating an average industry standard. The FMEA analysis identified critical failure points, such as machine maintenance issues causing faded logos (RPN 112) and poor material quality causing uneven surfaces (RPN 90), with recommendations for regular machine checks and better materials. Additionally, inadequate lighting was identified as a factor contributing to defects (RPN 75), with a solution to improve lighting. The implementation of the Kaizen method, through 5-S practices, focused on improving efficiency, cleanliness, and organization in the production process to reduce defects and enhance overall quality and productivity.

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