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Quality Control Analysis on MPGG Products Using Six Sigma DMAIC Method at PT Nugraha Potong Tekuk

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***Abstract**. Product quality is a key factor in enhancing a company's competitiveness. PT Nugraha Potong Tekuk, a producer of MPGG products, experienced a significant increase in the defect rate, reaching 11% of total production during the period from June 24 to July 16, 2024. This study aims to analyze the defect rate, identify the main causes, and provide improvement recommendations. The study follows the Six Sigma methodology, including the Define, Measure, Analyze, Improve, and Control (DMAIC) phases. Based on P-Chart analysis, the production process is within statistical control limits, but the defect rate still requires improvement. Two main types of defects were identified: unevenness and size defects, each accounting for 50% of the total defects. Fishbone diagram analysis revealed four main contributing factors: people, machines, materials, and environment. The people factor includes lack of operator skills and operator fatigue, while the machine factor covers worn-out tools and uncalibrated measuring instruments. The material factor is related to low-quality raw materials, and the environmental factor includes poor lighting and unstable work surfaces. Improvement recommendations include operator training, routine machine maintenance, quality control of raw materials, and improvement of the work environment. This study is expected to help PT Nugraha Potong Tekuk enhance product quality, reduce defect rates, and maintain competitiveness in the market.*

***Keywords** Product Quality, Six Sigma, Production Defects, Ergonomic Risk Analysis, Process Improvement*

1. INTRODUCTION

Quality is one of the key factors in enhancing a product’s competitiveness. Improving quality can reduce production costs and minimize waste. Product failures can be caused by various factors, such as raw materials, labor, production processes, equipment, machinery, or the work environment. Therefore, to maintain product quality and meet market demand, strict quality control is necessary in every activity and production process (Hidajat & Subagyo, 2022)

PT Nugraha Potong Tekuk is a leading manufacturing company specializing in the production of MPGG products. This product is a flagship item with a significant market share. However, in recent times, PT Nugraha Potong Tekuk has experienced a considerable increase in defective products. During the period from June 24 to July 16, 2024, the defect rate in MPGG production reached 11% of the total 200 units produced. The two main types of defects found were uneven defects and size defects, each amounting to 11 units or approximately 50% of the total defective products.

The increase in defective products not only leads to financial losses for the company but also threatens customer relationships, reduces consumer trust, and damages the company's reputation (Astini & Imaroh, 2021). Therefore, an analysis and process improvement effort is

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necessary to address this issue. One proven method for improving product quality and reducing defective products is the Six Sigma method with the Define, Measure, Analyze, Improve, Control (DMAIC) approach (Agustiandi et al., 2021). This systematic approach enables companies to identify root causes, measure defect levels, analyze data, implement improvements, and maintain control over the production process (Sutjipto et al., 2022). This research is expected to serve as an initial step in enhancing product quality and reducing the number of defective products, ensuring that PT Nugraha Potong Tekuk remains competitive and sustainable in an increasingly competitive market.

2. METHODS

Quality

Hangesthi et al., (2021)stated that product quality refers to the physical condition, function, and characteristics that can meet consumer preferences and needs satisfactorily, in proportion to the money spent. Meanwhile, Setiawan (2021) explained that quality is the achievement or even exceeding of customer expectations through the products provided by the company.

Quality Control

Quality control is a process carried out to ensure that the products produced by a company meet the expectations and predetermined standards (Masykur & Oktora, 2021). If non-conforming products are found, corrective actions must be taken to maintain quality. Quality control applies not only to goods but also to services and aims to ensure that the products meet the desired standards (Purilistianto et al., 2022).

Six Sigma

Six Sigma is a comprehensive and flexible method for controlling and improving product quality (Subana et al., 2021). This method relies heavily on data and facts, and focuses on understanding customer needs, efficient management systems, and continuous improvement (Nastiti et al., 2022). The implementation of Six Sigma involves five stages: define, measure, analyze, improve, and control.

a. Define

In this stage, the problem to be solved is identified. The main focus is to determine the defect characteristics of MPGG products. Tools used include SIPOC diagram and CTQ diagram (Ignatius & Sutanto, 2021).

b. Measure

This stage focuses on measurement to evaluate how well existing goals have been achieved, including measuring defect levels and sigma levels (Pranata Primisa Purba et al., 2022).

c. Analyze

In this stage, the causes of the problem are analyzed. The tool used is the fishbone diagram to identify the factors affecting the issue (Sutiyono et al., 2023).

d. Improve

This stage involves proposing action plans to solve the problem and improve product quality. The method used is 5W + 1H (Rucitra & Amna, 2021).

e. Control

The final stage involves documenting quality control results, standardization, and disseminating best practices that have been successful in improving the process (Sondakh & Wahyuningtyas, 2021).

3. RESULTS

Define

The first stage in implementing the Six Sigma method is Define, which aims to explain the existing problems. At PT Nugraha Potong Tekuk, the issue is the product defects of MPGG from June 24, 2024, to July 16, 2024. The SIPOC diagram is a process map that illustrates the flow from supplier to customer. It shows how earlier steps affect the subsequent ones.

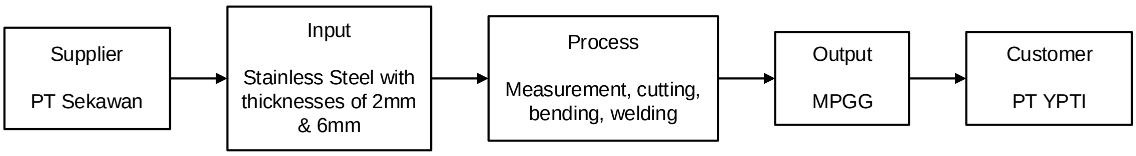

Figure 1. SIPOC Diagram

For the MPGG product, the supplier is PT Sekawan, which provides stainless steel raw materials with thicknesses of 2 mm and 6 mm. The production process involves measuring, cutting, comparing, and welding the materials, with the final output being the MPGG product sent to the customer, PT YPTI. This diagram maps the relationships between elements in the process to ensure smoothness and efficiency.

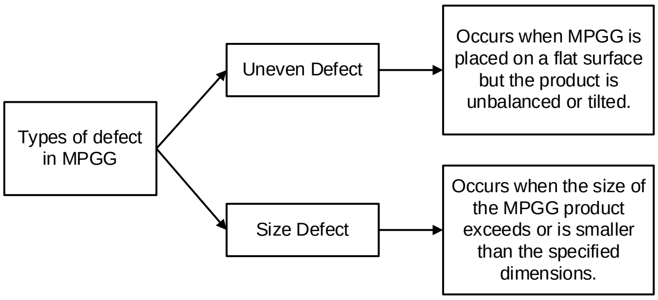

Figure 2. CTQ Diagram

CTQ Diagram The CTQ diagram is used to identify quality-related factors that are a priority for the customer. Based on the diagram, the defects found in MPGG products are uneven surfaces and size defects.

Measure

This stage discusses the results of measurements and calculations of the sigma value, as well as the measurement of defect limits from the sample data using control charts and Pareto diagrams. Based on the defect count in the MPGG PT Nugraha Potong Tekuk production process, defects occur in every production. Therefore, the defect count from each production is sampled. Then, an analysis is performed to determine whether the defects are still within statistical control limits using a control chart.

Table 1. Control Chart Calculation Data

Period	Production	Uneven Defect	Size Defect	Total	DPU	UCL	CL	LCL
24 June	10	1	1	2	0,2	0,407	0,11	-0,187
25 June	10	0	1	1	0,1	0,407	0,11	-0,187
26 June	10	0	1	1	0,1	0,407	0,11	-0,187
27 June	10	2	0	2	0,2	0,407	0,11	-0,187
28 June	10	0	2	2	0,2	0,407	0,11	-0,187
29 June	10	1	1	2	0,2	0,407	0,11	-0,187
30 June	10	0	0	0	0	0,407	0,11	-0,187
2 July	10	1	0	1	0,1	0,407	0,11	-0,187
3 July	10	0	1	1	0,1	0,407	0,11	-0,187
4 July	10	1	0	1	0,1	0,407	0,11	-0,187
5 July	10	1	0	1	0,1	0,407	0,11	-0,187
6 July	10	0	0	0	0	0,407	0,11	-0,187
8 July	10	1	0	1	0,1	0,407	0,11	-0,187
9 July	10	0	2	2	0,2	0,407	0,11	-0,187
10 July	10	1	0	1	0,1	0,407	0,11	-0,187
11 July	10	0	1	1	0,1	0,407	0,11	-0,187
12 July	10	1	0	1	0,1	0,407	0,11	-0,187
13 July	10	0	0	0	0	0,407	0,11	-0,187
15 July	10	0	1	1	0,1	0,407	0,11	-0,187
16 July	10	1	0	1	0,1	0,407	0,11	-0,187
Total	200	11	11	22				

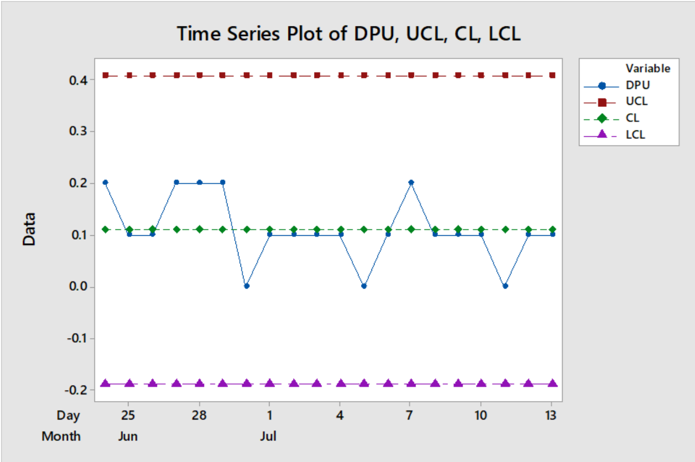

Figure 3. Control Chart Map

Based on the control chart graph, it can be concluded that the data is in control because all the data points fall within the control limits, meaning no data exceeds the UCL or LCL.

Table 2. Sigma Level and DPO Measurement Data

Period	Production	Uneven Defect	Size Defect	Total	DPU	DPO	DPMO	Sigma Value	CTQ
24 June	10	1	1	2	0,2	0,1	100000	2,782	2
25 June	10	0	1	1	0,1	0,1	100000	2,782	1
26 June	10	0	1	1	0,1	0,1	100000	2,782	1
27 June	10	2	0	2	0,2	0,2	200000	2,342	1
28 June	10	0	2	2	0,2	0,2	200000	2,342	1
29 June	10	1	1	2	0,2	0,1	100000	2,782	2
30 June	10	0	0	0	0	0	0	0	0
2 July	10	1	0	1	0,1	0,1	100000	2,782	1
3 July	10	0	1	1	0,1	0,1	100000	2,782	1
4 July	10	1	0	1	0,1	0,1	100000	2,782	1
5 July	10	1	0	1	0,1	0,1	100000	2,782	1
6 July	10	0	0	0	0	0	0	0	0
8 July	10	1	0	1	0,1	0,1	100000	2,782	1
9 July	10	0	2	2	0,2	0,2	200000	2,342	1
10 July	10	1	0	1	0,1	0,1	100000	2,782	1
11 July	10	0	1	1	0,1	0,1	100000	2,782	1
12 July	10	1	0	1	0,1	0,1	100000	2,782	1
13 July	10	0	0	0	0	0	0	0	0
15 July	10	0	1	1	0,1	0,1	100000	2,782	1
16 July	10	1	0	1	0,1	0,1	100000	2,782	1
Total	200	11	11	22	2,2	2	2000000	45,967	19
Average	10	1,1	1,222	1,1	0,11	0,118	117647,1	2,7039	0,95

Based on data processing, it can be determined that PT Nugraha Potong Tekuk has a capability level based on DPMO of 2.70 ≈ 3 sigma, with a defect rate of 117,647 per million production opportunities. This could lead to losses if not addressed promptly and accurately.

Analyze

In the analysis stage, we will discuss the causes of defects in the MPGG product, looking at four factors: human, machine, material, and environment. The tools used in this stage are the Pareto chart and the cause-and-effect diagram (fishbone diagram). The Pareto chart is used to determine the percentage of defects and identify the main problems or the most dominant defects. After understanding the defect percentages and types in each process, the next step is to create the Pareto chart. In this chart, we can identify the most dominant defects in MPGG production at PT Nugraha Potong Tekuk.

Table 3. Pareto Diagram of Defect Types

Types of defect	Ratio	Cumulative Percentage
Uneven defect	11	50,00%
Size defect	11	50,00%
Total	22	100 %

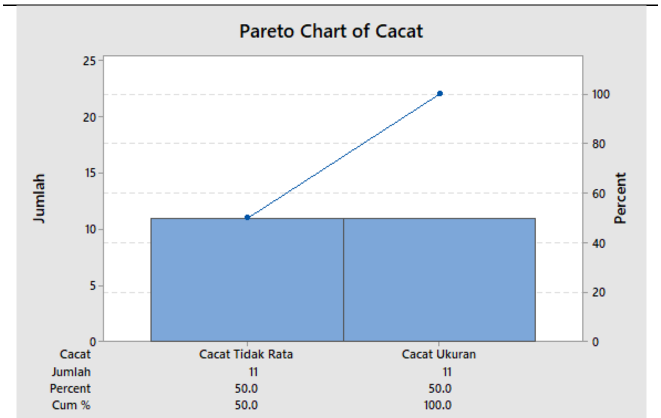

Figure 4. Pareto Diagram of Defect Types

Based on the graph, it can be seen that there is no dominant defect because each type of defect has the same percentage, which is 50%. The total defect percentage for both types is 100%. To improve quality and address the issues in the MPGG production process, based on the Pareto graph, the company needs to find solutions to identify the causes of defects based on human, machine, material, and environment factors. Then, to identify the causes of uneven defects and size defects, the fishbone diagram can be used.

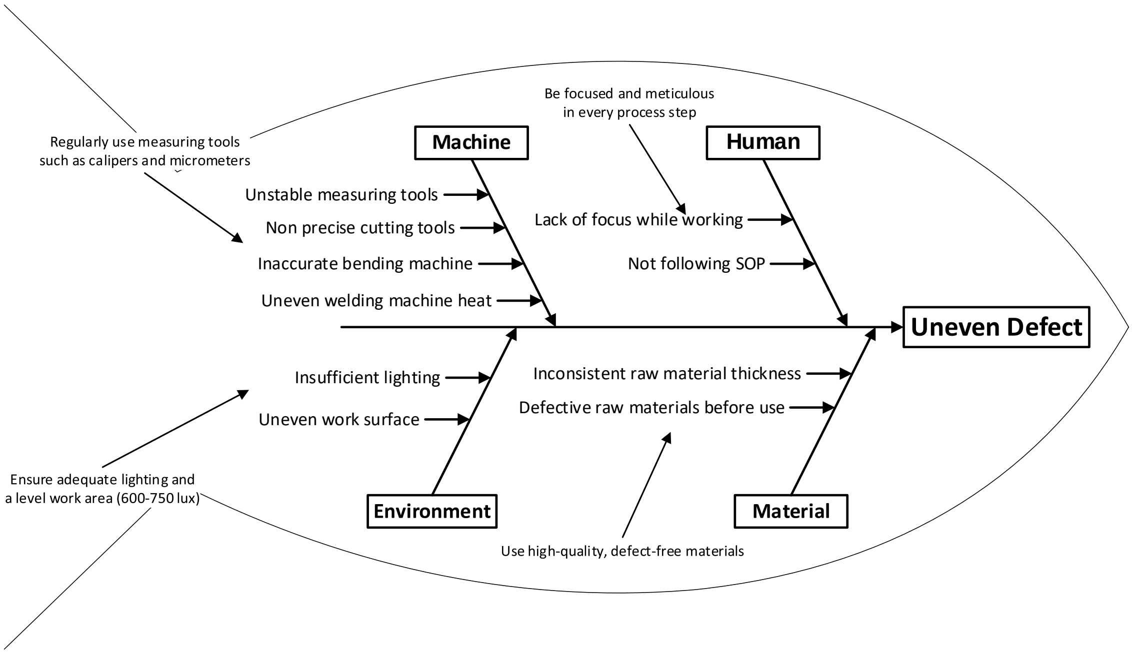

Figure 5. Cause and Effect Diagram

The Fishbone Diagram identifies four main factors: people, machines, materials, and environment. Irregular defects are caused by the operator's lack of skill, poorly maintained machines, inconsistent raw materials, and poor working conditions. Size defects occur due to measurement errors, unstable measuring tools, low-quality raw materials, and poor lighting.

Improve

At this stage, improvements will be suggested based on the analysis using the fishbone diagram. After the analysis results are known, the next step is to find the causes of defects and propose improvements for the defective MPGG product. Based on the types of defects, improvements will be suggested to reduce defects using the 5W + 1H method, as shown in the table below.

Table 4. 5W + 1H MPGG Defects

What	Where	Why	Who	When	How
Reduce defects in MPGG products	PT Nugraha Potong Tekuk Plat	1. Human: Measurement errors, lack of welding skills, and inaccurate comparison. 2. Machines: Inaccurate banding machine, unstable measuring	All employees in production at PT Nugraha Potong Tekuk Plat	During the production process	1. Human: Regular training, consistent work schedule, sufficient breaks, and regular inspections. 2. Machines: Routine maintenance, parts replacement, and checking the stability of the

	tools, uneven heat from welding machine, imprecise cutting tools. 3. Materials: Defective raw materials, uneven thickness. 4. Environment: Poor lighting (300-500 lux), uneven work area.	welding machine's heat. 3. Materials: Strict inspection of raw materials, collaboration with suppliers, and sorting defective materials. 4. Environment: Ensure the work area is level, lighting is adequate (600-750 lux), and keep the area clean.

Uneven defects are caused by factors such as operator errors, inaccurate equipment, inconsistent raw materials, and poor working conditions. The proposed solutions include regular operator training, equipment maintenance and calibration, stricter raw material selection, and improving work conditions, such as enhancing lighting with 600-750 lux white LED lights and ensuring workplace stability.

Control

The control phase is the final step in the Six Sigma methodology, aiming to ensure that product quality improvements are consistently maintained. The focus of improvement is on four main factors that cause defects: people, machines, materials, and environment.

For the human factor, regular training is essential to improve operator skills. In addition, implementing clear SOPs, conducting regular work inspections, and managing work schedules with adequate rest time help maintain operator consistency. For the machine factor, routine maintenance and equipment checks are necessary. Replacing worn-out tools and regularly inspecting machines will ensure stability and accuracy during production. For the material factor, inspecting the quality of raw materials before use is crucial. Collaborating with trusted suppliers ensures that the materials meet standards and reduces the risk of defects. The environmental factor is also very important. Ensuring optimal lighting, using white LED lights with an intensity of 600-750 lux, as well as maintaining a clean and organized workspace, supports production efficiency and quality.

4. CONCLUSION

Based on the control chart (P-Chart) analysis, the defect rate is within statistical control limits, indicating that the production process is stable. However, with an 11% defect rate and a DPMO of 117,647, equivalent to a sigma level of about 3, improvements are needed to reduce potential losses. The Pareto chart shows that both types of defects have equal proportions of 50%, requiring balanced handling. The fishbone diagram analysis identifies four main causes of defects: people, machines, materials, and environment. People-related factors include lack of operator skills, fatigue, and low attention to detail. Machine-related issues include worn tools, inconsistent heat distribution, and uncalibrated measuring instruments. Material factors involve thickness inconsistencies and poor material quality. Environmental factors include inadequate lighting and uneven work surfaces. Suggested improvements include periodic operator training to enhance skills and attention to detail, routine machine maintenance, raw material quality control, and improving the working environment. In addition, implementing clear standard operating procedures (SOPs) can help improve quality and production efficiency.

The company should conduct more frequent training for operators to improve their skills and attention to detail, thereby reducing errors caused by fatigue or lack of focus. Additionally, machines and measuring tools should be regularly maintained and checked, as well-maintained machines lead to higher-quality products and fewer defects. Further research is also needed to understand the impact of environmental factors, such as temperature and lighting, as well as raw material quality, on product defects. This research can help the company improve the work environment and select better raw materials to reduce product defects.

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