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Minimizing Defects in Radiator Grille Upper Garnish Parts using Six Sigma (DMIC) at PT. AAS

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Abstract *– To achieve quality improvement, companies must align their production processes with customer needs, control production costs effectively, and maintain product quality. This approach enhances customer satisfaction, increases market share, and boosts profitability. PT. AAS, an automotive company specializing in injection molding and painting, relies on resin as its primary raw material to produce car parts for major clients like Hyundai, Suzuki, and Astra. To dominate the market, PT. AAS must prioritize delivering quality products on time to earn customer trust and secure continuous orders. Initially, the QC data for the injection molding area showed a high defect rate of approximately 17.5% for the Garnish Radiator Grille Upper part, from December 2022 to May 2023. Prior to implementing the Six Sigma method, PT. AAS had a DPMO (Defects Per Million Opportunities) value of 58,177, equivalent to a 3.10 Sigma level. After applying the Six Sigma DMAIC (Define, Measure, Analyze, Improve, Control) process, the DPMO decreased to 17,991, resulting in a 3.60 Sigma level. This suggests that PT. AAS currently operates at a 4 Sigma level, with a strong potential to reach 5 or even 6 Sigma by addressing the root causes of rejection. The fishbone analysis highlights the need for action across all departments, including Management. Key areas to focus on include Material, ensuring the correct resin delivery to the Injection Molding station; Machine, verifying proper machine settings and utilizing the 5S methodology; Environment, optimizing room temperature and ventilation; and Man, providing training to enhance operators' knowledge and sense of responsibility.*

Keywords: *Six Sigma; DMAIC; Quality Analysis*

I. INTRODUCTION

Typically, every organization will aim to guarantee that its products align with customer requirements and preferences. This enables the company to enhance product quality in accordance with the established design and specifications. (Antony et al., 2012; Suryaningrat et al., n.d.; Wang et al., 2011).

PT. AAS is an automotive company engaged in injection molding and painting, producing car parts with the main raw material used being resin. The final product will be sent to large customers such as Hyundai, Suzuki, and Astra, to be processed and assembled into a whole unit of the car. PT. AAS must be able to meet customers' needs and needs to dominate market share. If PT. AAS must control market share, the main priority is that the company's profits must increase by maintaining the quality of the final product and delivery on time so that customers trust and will place continuous orders to PT. AAS.

One method that can be used to control product quality is Six Sigma (Antony et al., 2012). Six Sigma aims to reduce defects and increase product value. Six Sigma can also reduce process variability as well as product or service defects by statistical methods and troubleshooting tools (Adeodu et al., 2023).

Table I. Data Produce, Reject & Product OK Part Garnish Radiator Grille Upper

Item	End of Dec 2022 – May 2023	Average per day (n-78 days produced)	% Average per day
Total Qty Produce	3369	43.19230769	100%
Total Qty Reject	588	7.538461538	17.5%
Total Qty OK	2781	35.65384615	82.5%

Table II. Type Reject (Period end of Dec 2022 - May 2023)

Type Reject	Qty Reject	%Reject
Shrink Mark	39	6.6%
Scratch	221	37.6%
Burr	3	0.5%
Bubble	50	8.5%
Shrinked/Bending	13	2.2%
Dent	243	41.3%
Dirty	19	3.2%
TOTAL	588	100%

Observing the elevated rate of daily product rejections has prompted the author to conduct data analysis and employ the Six Sigma methodology with the DMAIC approach for quality control, aimed at reducing product rejections (Show in Table I & II).

Quality control serves the purpose of producing products or services that align with established requirements and standards (Antony et al., 2012; Kholil, 2022). It also involves efforts to enhance and sustain the quality of products that fall short of established standards. Quality control is a systematic strategy designed to achieve, manage, and enhance product quality to meet predetermined criteria and satisfy customer expectations to the best extent possible.

The research methodology employed in this study is the Six Sigma approach, a quality control and improvement method pioneered by Motorola in 1986 (Byrne et al., 2021; Gijo et al., 2014). Six Sigma sets a target of achieving 3.4 Defects Per Million Opportunities (DPMO) for all products, encompassing both goods and services, with the aim of reducing defect occurrence.

Furthermore, Six Sigma can be described as a business process improvement method with the objectives of identifying and mitigating factors contributing to defects, reducing cycle times and production costs, enhancing productivity, fulfilling customer demands, optimizing machine utilization, and achieving superior results in production and service.

The term "Six Sigma" derives from the combination of "six," signifying six standard deviations, often symbolized as σ. Higher sigma values correlate with improved quality, indicating lower levels of defects or failures, as illustrated in the Sigma Value Conversion table (Show in Table III).

Table III. Sigma Value Conversion table

Long-term yield (basically the percentage of successful output) %	Defect Per Million Opportunities (DPMO)	Processes Sigma
99.99966	3.4	6
99.98	233	5
99.94	6.210	4
99.73	66.807	3
69.1	308.538	2
30.9	691.462	1

The application of Six Sigma with DMAIC Stages involves a structured approach to quality improvement comprising five sequential steps, as outlined by the DMAIC concept (Define, Measure, Analyze, Improve, Control).

- **Define:** In the Define phase, the primary objective is to identify and prioritize the issues at hand, essentially defining the problem's scope and significance.
- **Measure:** The Measure phase is focused on quantifying the extent of production defects. It entails calculating metrics such as DPMO (Defects Per Million Opportunities) and DPU (Defects Per Unit) to gauge the quality performance.
- **Analyze:** During the Analyze phase, the root causes behind the production problems are pinpointed. This stage often involves the use of a causal diagram, such as a fishbone diagram, to analyze and identify the key factors contributing to the observed issues.
- **Improve:** The Improve phase is dedicated to enhancing the production process and eliminating the root causes of defects as determined in the Analyze phase.
- **Control:** Finally, the Control phase aims to sustain the improved performance and prevent the recurrence of the primary defect-causing issues. It involves establishing rigorous control mechanisms for ongoing activities to ensure consistent results while minimizing time, problems, and unnecessary costs.

II. METHODS

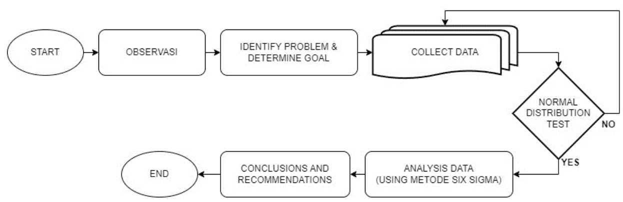

Figure 1. Research Flow Chart

This research (Show in Figure 1) was carried out within the domain of an automotive company specializing in injection molding and painting, specifically PT. AAS. PT. AAS specializes in manufacturing car components, primarily utilizing resin as the principal raw material. These finalized components are then dispatched to prominent clients, including Hyundai, Suzuki, and Astra, where they undergo further processing and assembly into complete automobile units. The research project spanned from December 2022 to May 2023, with a primary focus on identifying types of defects and devising strategies to mitigate them through the application of the Six Sigma methodology. The object studied in this study was the company's production process. According to the field survey, there were still defective products such as Shrink Mark, Scratch, Burr, Bubble, Shrinked/Bending, Dent, and Dirty.

To collect data for this study, multiple methods were employed, which encompassed the following approaches:

- Examination of records and documentation provided by the company, pertinent to the research.
- Interviews conducted with workers and employees within the production department to gain insights into the underlying causes of defects.
- Direct field observations and in-depth examination of the production processes.

The Six Sigma methodology served as the primary framework for data analysis and processing in this research. The application of Six Sigma with DMAIC Stages involves a structured approach to quality improvement comprising five sequential steps, as outlined by the DMAIC concept (Define, Measure, Analyze, Improve, Control).

- **Define**: In the Define phase, the primary objective is to identify and prioritize the issues at hand, essentially defining the problem's scope and significance.
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III. RESULTS AND DISCUSSION

In the realm of academia and research, the normality test plays a crucial role, especially in quantitative research. The normality test assesses whether the residual values in the data exhibit a normal distribution. Data that adheres to a normal distribution pattern minimizes the potential for bias. Essentially, the normality test compares the research data under examination with a normally distributed dataset possessing the same mean and standard deviation, thereby verifying the data's conformity to the normal distribution assumption.

3.1 Distribution Normal

The data pertaining to the Quality Garnish-R/Grille UPR at PT AAS for the period from December 2022 to May 2023 was subjected to examination for normal distribution using the Minitab software program. The outcomes of this analysis are illustrated in Figure 2 below.

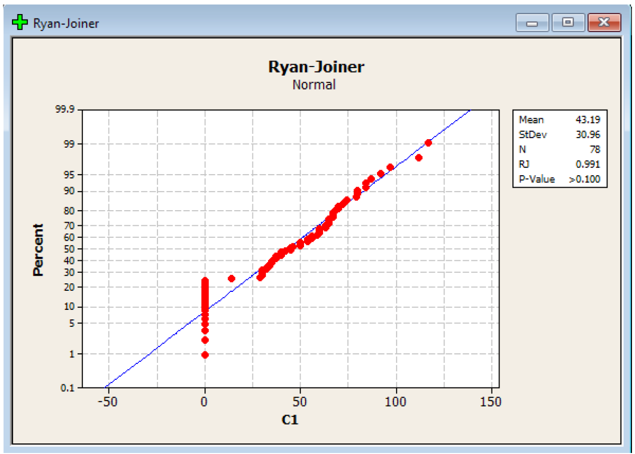

Figure 2. Picture Normal Distribution Testing Chart (using tests for Normality Ryan-Joiner)

- Reject H0 if p-value (p-value) or sig < 0.05 its mean distribution is said to be abnormal.
- Accept H0 if p-value (p-value) or sig > 0.05 its mean distribution is said to be normal.

Judging from the graph above, the data can be said to be normally distributed, so that the data in this study can be continued using these data.

3.2 SIX SIGMA

Furthermore, the data is processed using the Six Sigma method, with DMAIC stages (Define, Measure, Analyze, Improve, Control).

3.2.1 Define Stage

At this stage, several things are done, namely:

- Describe the production process of Garnish-R/Grille UPR using a flow chart (Show in Figure 3).

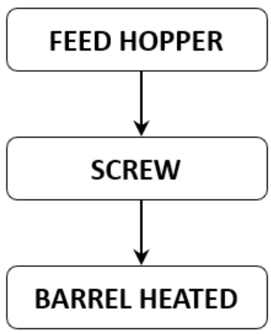

Figure 3. Flow chart Produce Garnish-R/Grille UPR

The machine operates by initially receiving resin grains in the feed hopper. As the resin progresses through the machine, the screw mechanism generates heat due to friction. Consequently, the resin reaches its targeted temperature, undergoes melting, and subsequently gets injected into the mold cavity. This molten resin then goes through a cooling process, ultimately taking on the desired pattern in accordance with the mold's design.

- SIPOC (Supplier-Input-Process-Output-Customer) diagramming

The objective is to establish a strategic plan within the Six Sigma framework, with SIPOC diagrams being among the most valuable and commonly employed tools for illustrating workflow processes (Show in Figure 4).

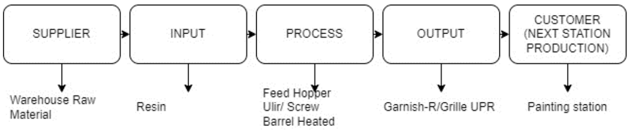

Figure 4. Diagram SIPOC Garnish-R/Grille UPR

DPMO = (D / (U x O)) x 1,000,000
DPMO = (588/ (3369 x 3)) x 1,000,000 = 58,177

Prior to implementing the Six Sigma methodology, the DPMO (Defects Per Million Opportunities) stood at 58,177 for a production of one million Garnish-R/Grille UPR units, corresponding to a 3.10 Sigma level.

3.2.2 Measure Stage

This stage is the data collection stage used to measure process performance (Show in Figure 5).

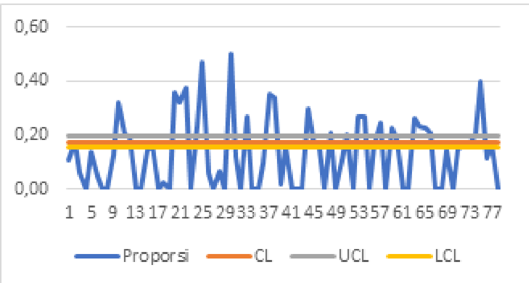

Figure 5. Control Map P part Garnish-R/Grille UPR

Examining data from December 2022 to May 2023, it becomes evident that only a limited portion of the data falls within the control limits, while a substantial portion lies outside the upper control limit (UCL) and lower control limit (LCL).

Table IV. Calculating Percentage Reject based on Type Reject part Garnish-R/Grille UPR

Type Reject	Qty Reject	Qty Cumulative Reject	% Reject	% Cumulative Reject
Shink Mark	39	39	6.6%	6.6%
Scratch	221	260	37.6%	44.2%
Burr	3	263	0.5%	44.7%
Bubble	50	313	8.5%	53.2%
Shrinked/Bending	13	326	2.2%	55.4%
Dent	243	569	41.3%	96.8%
Dirty	19	588	3.2%	100%
TOTAL	**588**		**100%**	

DPMO = (D / (U x O)) x 1,000,000
DPMO = (588/ (3369 x 7)) x 1,000,000 = 17,991

Following the implementation of the Six Sigma approach, the DPMO (Defects Per Million Opportunities) has decreased to 17,991 for a production of one million Garnish-R/Grille UPR units, reaching a 3.60 Sigma level. This indicates that PT AAS currently operates at a 4 Sigma level, with a significant potential for progressing to a level 5 or even 6 Sigma if the company effectively tackles the root causes of rejection (Show in Table IV).

3.2.3 Analyze Stage

The process of pinpointing the fundamental reasons behind defects is conducted through data analysis employing fishbone diagrams. During the analysis phase, efforts are directed toward identifying the root causes of the issue as well as potential enhancements that can be implemented (Show in Figure 6).

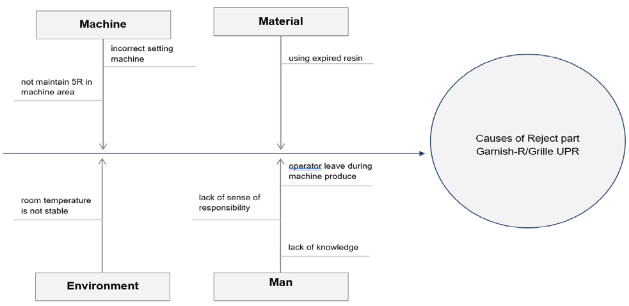

Figure 6. Fishbone Causes Reject Part Garnish-R/Grille UPR

3.2.4 Improve Stage

Based on the insights gleaned from the fishbone diagram analysis, it is recommended that all departments, including Management, take proactive steps. These actions should center around the following areas:

- **Material**: Ensure that the operators in the warehouse accurately deliver the appropriate resin to the Injection Molding station.
- **Machine:** Verify that all operators correctly configure the machine settings before initiating production and consider implementing the 5R methodology for process improvement.
- **Environment:** Adjust the room temperature and incorporate additional equipment, such as fans near the machine, to optimize the working environment.
- **Man:** Provide training to equip all operators with enhanced knowledge and a heightened sense of responsibility

3.2.5 Control Stage

This phase is known as the control stage, which involves overseeing whether the production process has operated according to the anticipated standards, typically involving regular monitoring of the relevant operators.

IV. CONCLUSION

Based on this study's findings, the following conclusions can be drawn:

1. Prior to implementing the Six Sigma method, PT AAS had a DPMO value of 58,177 for one million

Garnish-R/Grille UPR units, equating to a 3.10 Sigma level. However, post-application of the Six Sigma method, the DPMO value improved to 17,991 for one million Garnish-R/Grille UPR units, reaching a 3.60 Sigma level. This suggests that PT AAS currently operates at a 4 Sigma level, with a significant potential to attain levels 5 or even 6 Sigma by effectively addressing the causes of rejection.

2. Detailed insights from the fishbone analysis highlight the need for all departments, including Management, to follow up and concentrate on specific areas:
   - Material: Ensuring accurate delivery of the correct resin by warehouse operators to the Injection Molding station.
   - Machine: Confirm that all operators correctly configure machine settings prior to starting operations and considering the implementation of the 5R approach.
   - Environment: Making necessary room temperature adjustments and providing additional equipment, such as fans near the machines, to enhance the working environment.
   - Human Resources: Conducting training programs to enhance operator knowledge and cultivate a stronger sense of responsibility among the workforces.

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