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Quality Control Analysis of Hard Solder Assembly (HSA) of Key Flutes Using the Six Sigma DMAIC Method (Case Study: PT. Yamaha Musical Products Indonesia)

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Abstract

Quality control is a critical aspect of manufacturing industries to ensure product consistency and minimize defect, and propose quality improvement actions using rates. PT. Yamaha Musical Products Indonesia a manufacturer of wind musical instruments, still encounters quality issues in the Hard Soldering Assembly (HSA) Key-Flute product that affect production efficiency. This study aims to identify dominant defect types, evaluate process performance the Six Sigma DMAIC (Define, Measure, Analyze, Improve, and Control) approach. The study utilizes production and defect data collected during June 2025. The measurement stage shows an average Defect Per Million Opportunities (DPMO) value of 2,738.42 with a Sigma Level of 4.29, indicating that the process performance is not yet optimal. Pareto analysis reveals that the Ro Tare defect contributes more than 80% of total defects. Root cause analysis using a fishbone diagram identifies human, machine, method, and material factors as the main causes. Proposed improvements include operator retraining, work standardization, machine maintenance, material quality control, and manpower optimization to enhance process stability.

Keywords: Six Sigma; DMAIC; Quality Control; Hard Soldering Assembly; Key Flute

INTRODUCTION

In an era of increasingly intense industrial competition, manufacturing companies are required to produce products with consistent quality in accordance with established standards. Product quality not only affects customer satisfaction (Firmansyah & Yuliarty, 2020), but also has a significant impact on production efficiency, operational costs, and overall company competitiveness. High defect rates can lead to material waste, increased production costs, and reduced productivity, making quality control a critical component of manufacturing systems (Lestari & Purwatmini, 2021).

One widely applied approach in quality control and process analysis is Six Sigma (Permadi & Agustina, 2022). Six Sigma is a data-driven and statistical methodology aimed at reducing process variation and minimizing defects to near-zero levels. This methodology is commonly implemented through the DMAIC framework (Define, Measure, Analyze, Improve, and Control) (Suryatman *et al.*, 2020), which provides a structured sequence for problem identification, process performance measurement, root cause analysis, and the formulation of improvement and control strategies (Rahman & Perdana, 2021). Previous studies have demonstrated that the application of Six Sigma DMAIC can effectively enhance process capability and reduce defect occurrences in manufacturing environments (Adi Juwito & Ari Zaqi Al-Faritsy, 2022; Abdul Azis Fitriaji & Aswin Domodite, 2022).

PT. Yamaha Musical Products Indonesia is a manufacturing company in the wind musical instrument industry that produces various flute components, including the Hard Soldering Assembly (HSA) Key-Flute. In the production of this component, particularly during the soldering process, product defects are still frequently encountered, affecting both production efficiency and process stability. The presence of recurring defects indicates that the existing quality control practices have not yet achieved optimal performance and require systematic evaluation and analysis (Company internal data, 2025).

Based on these conditions, this study aims to analyze quality control in HSA Key-Flute products using the Six Sigma method with a DMAIC approach (Wahyuni & Sulistyowati, 2020). The research focuses on identifying dominant defect types, evaluating production process performance through Defect Per Million Opportunities (DPMO) and Sigma Level analysis, and analyzing the root causes of defects (Suryatman *et al.*, 2020). Furthermore, this study proposes improvement recommendations and control plans derived from the analysis results to support defect reduction efforts and enhance the stability of the production process.

METHODS

This study employs a quantitative descriptive research approach to analyze quality control in the Hard Soldering Assembly (HSA) Key Flute production process at PT. Yamaha Musical Products Indonesia. The analysis is conducted using the Six Sigma methodology, which is widely applied in manufacturing industries to evaluate process performance and reduce defect occurrence through data-driven and statistical analysis Sigma (Permadi & Agustina, 2022;Suryatman *et al*., 2020). The Six Sigma approach is implemented using the DMAIC framework (Define, Measure, Analyze, Improve, and Control), which provides a structured procedure for identifying quality problems and analyzing their causes (Rahman & Perdana, 2021).

The object of this research is the HSA Key Flute product, particularly in the soldering process, which plays a critical role in determining the final product quality. The data used in this study consist of secondary data obtained from the company's internal production records, including total production output and defect data during the observation period. These data represent actual production conditions and are commonly used in quality control studies to assess process capability and defect characteristics (Wahyuni & Sulistyowati, 2020).

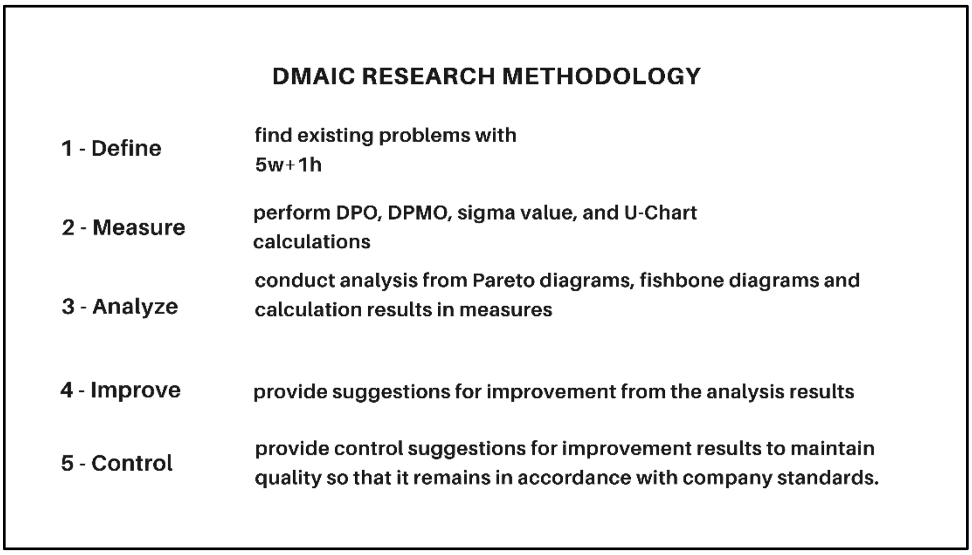

Figure 1. DMAIC Research Methodology

Data analysis is carried out according to the DMAIC stages. In the **Define** stage, critical quality characteristics and defect categories are identified based on defect data evaluation and process observations, as suggested in previous Six Sigma studies (Suryatman *et al*., 2020). The **Measure** stage involves evaluating process performance using Defect Per Million Opportunities (DPMO) and Sigma Level calculations, which are standard indicators for measuring process capability and defect rates in Six Sigma applications (Rahman & Perdana, 2021; Adi Juwito & Ari Zaqi Al-Faritsy. 2022). Statistical process control tools are also used to assess process stability during this stage.

In the **Analyze** stage, Pareto analysis is applied to identify dominant defect types based on the 80/20 principle, followed by fishbone diagram analysis to determine the root causes of defects related to manpower, methods, machines, materials, and environment. This combination of analytical tools is widely recommended in Six Sigma-based quality control studies to support systematic root cause identification (Suryatman *et al*., 2020; Abdul Azis Fitriaji & Aswin Domodite, 2022).

The **Improve** stage in this study is limited to the formulation of proposed improvement actions derived from the analysis results, while the **Control** stage is presented in the form of a proposed statistical control plan using a p-chart to support defect proportion monitoring and process stability. These stages are provided as recommendations without direct implementation, in accordance with the research scope and commonly applied practices in analytical Six Sigma studies (Wahyuni & Sulistyowati, 2020).

RESULT AND DISCUSSION

Based on the processing of production data and product defects of Hard Soldering Assembly (HSA) Key-Flute in June 2025, the total production was 102,140 units with 2,522 defective units. The types of defects identified include Ro Tare, Ro Tsuki, Ro Oi, Gosong, Toke, Bari, Kizu, Dimension, and Other. The results of measuring process performance using the Six Sigma method show an average value of Defects Per Million Opportunities

(DPMO) of 2,738.42 with a Sigma Level value of 4.29. This value indicates that the production process is in the fairly good category, but has not yet reached the ideal Six Sigma performance target.

Tabel 1. Calculation of Six Sigma

Due Date (2025)	Total NG HSA (Pcs)	Production/day (Pcs)	DPMO	SIGMA Level
4 june	110	6060	1998.533	4.38
5 june	50	6060	916.7583	4.62
9 june	107	5720	2078.477	4.37
10 june	144	6140	2243.938	4.34
11 june	160	7680	2314.815	4.33
12 june	184	5900	3201.507	4.23
13 june	132	6620	2098.019	4.36
16 june	154	6220	2572.347	4.30
17 june	137	5440	2798.203	4.27
18 june	260	6720	3786.376	4.17
19 june	197	6000	3611.111	4.19
20 june	222	6380	3483.107	4.20
23 june	282	6780	3982.301	4.15
24 june	223	6420	3271.028	4.22
25 june	163	7400	2192.192	4.35
26 june	204	6600	3265.993	4.22
Average			2738.419	4.29

Process stability analysis using a U-chart control chart (Shiyamy *et al*., 2021). how's that most data points are within the control limits, but some production periods are outside the upper control limits. This condition indicates that the production process is not yet fully stable and is still affected by specific variations that require further attention.

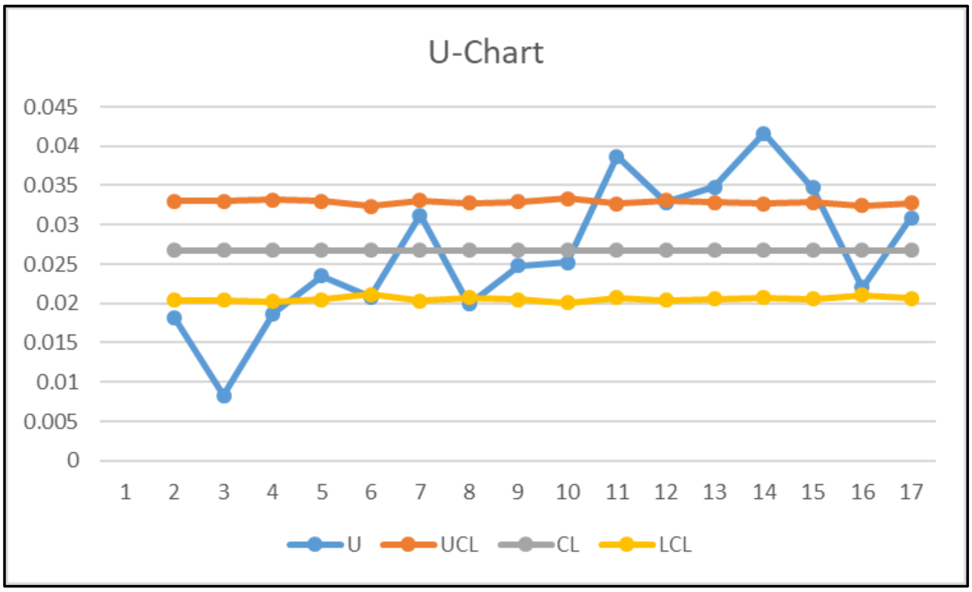

Figure 2. U-Chart

The Pareto diagram analysis shows that the Ro Tare defect type is the most dominant defect, contributing more than 80% of the total product defects. Other defects, such as Burnt, Ro Tsuki, and Ro Oi, contribute much less. Therefore, quality improvement should prioritize Ro Tare defects to significantly reduce the number of defective products. The terms used within the company for these types of defects are as follows:

1. Ro Tare : solder drips
2. Ro Tsuki : solder does not adhere properly
3. Ro Oi : excess solder
4. Toke : melted solder
5. Bari : sharp chips from cutting
6. Kizu : scratches
7. Gosong : burnt

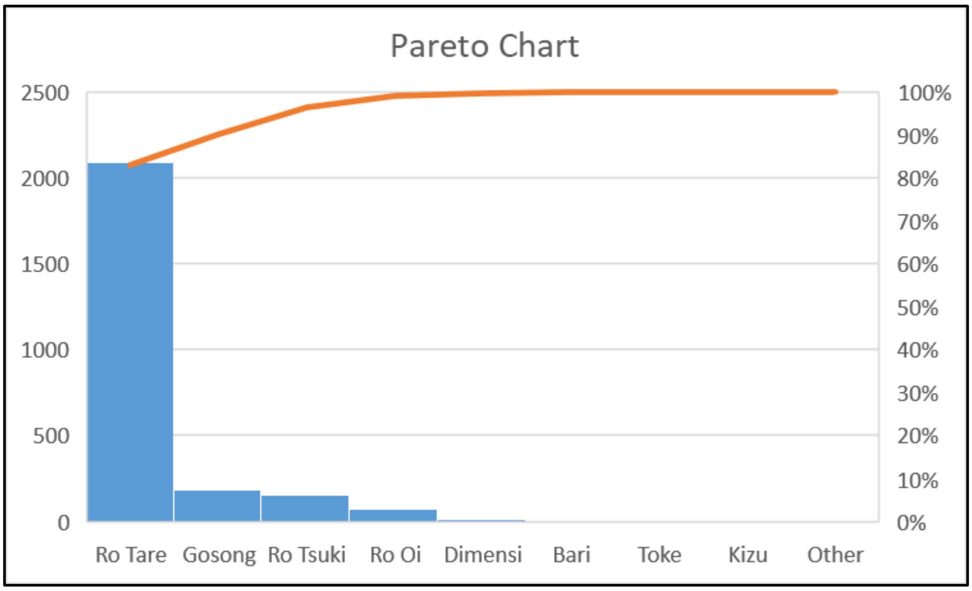

Figure 3. Pareto diagram of defective products

Next, a root cause analysis using a fishbone diagram (Terawati & Wiguna, 2021) showed that product defects were influenced by four main factors: human, machine, method, and material. Human factors included uneven operator skills and work fatigue; machine factors related to unstable soldering temperatures and worn jigs; method factors related to non-compliance with soldering techniques and SOPs; and material factors included inconsistent solder tin quality.

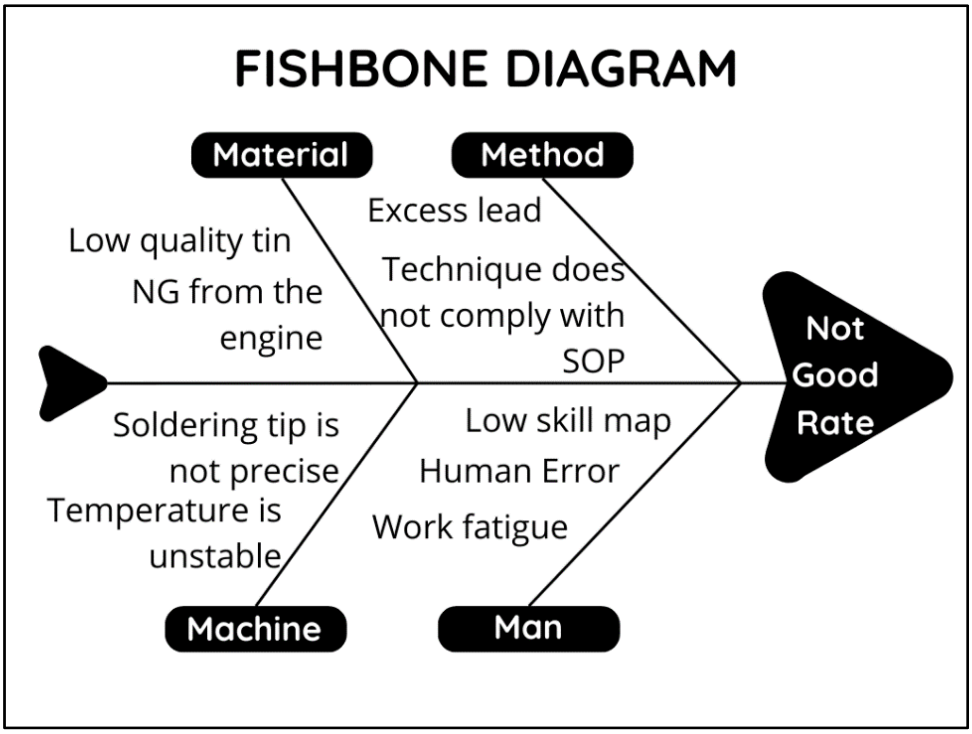

Figure 4. Fishbone Diagram

Measurement results show that the HSA Key-Flute production process is at a sigma level of 4.29, indicating that the process is sufficiently controlled but still has room for improvement. This value indicates good process quality, but has not yet reached world-class industry standards, requiring continuous improvement to reduce product variation and the number of defects. Pareto analysis shows that Ro Tare defects are the dominant defect, contributing more than 80% to total defects. Therefore, improvements focused on this defect have the potential to significantly impact product quality improvement. Fishbone analysis results indicate that human factors and methods are the main causes of defects, particularly related to inconsistencies in soldering techniques and a lack of work standardization. Based on these findings, proposed improvements include operator retraining, implementation of visual SOPs, soldering machine maintenance and calibration, material quality control, and adjustments to manpower arrangements. Implementation of these improvements is expected to reduce defect rates, increase process stability, and support continuous quality performance improvement (Yuanitasari *et al*., 2024).

CONCLUSION

Based on the research results, it can be concluded that the performance of the Key-Flute Hard Soldering Assembly (HSA) production process at PT. Yamaha Musical Products Indonesia is at a sigma level of 4.29 with a DPMO value of 2,738.42, which indicates that the process is quite controlled but not yet optimal. Pareto analysis shows that Ro Tare defects are the dominant defect with a contribution of more than 80% of the total product defects. The results of the root cause analysis using a fishbone diagram identified human factors and methods as the main causes of defects. The proposed improvements formulated through the Six Sigma DMAIC approach include improving operator skills, implementing work standardization, soldering machine maintenance, material quality control, and manpower management. The implementation of these proposed improvements is expected to reduce the level of defects, increase the stability of the production process, and encourage continuous improvement in quality performance.

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