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Analysis Capability Process of Fuel Tank Production: A Case Study in Manufacturing Industry

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A B S T R A C T

The competition in the automotive industry is increasingly challenging, where the company's task of ensuring customers are satisfied with the products we produce is the main factor in winning them. That is the value of the manufacturing industry to continuously improve quality. Another case is experienced by the fuel tank manufacturing industry, where the products produced are still rejected. This study aims to reduce the reject rate and determine the priority of problems in the fuel tank production process. This study uses the six sigma method based on a simple problem-solving methodology consisting of Define, Measure, Analyze, Improve and Control. This method combines various statistical tools and other process improvement approaches. The results of this study show that the company's Sigma level in February carried out in the welding & press section obtained a sigma value of 4.0 and process capability of 1.34. This means that the quality control process that has been carried out has not been going well because the product is defective and still needs to be improved. Finally, this paper provides some recommendations for improving process capability.

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1. Introduction

The growth potential of the automotive industry in Indonesia shows a positive trend. During the COVID-19 crisis in early 2020 spurred the automotive industry to continue to improve marketing and product quality. That is proven by the growth of the automotive industry since the 3rd quarter of 2020.

Figure 1 shows sales trends in the automotive industry in Indonesia. This trend has spurred every automotive company to improve the quality of its products. The research was conducted in one of the manufacturing industries that is one of the players in the automotive industry and also a leading company in Indonesia. They produced vehicles, both cars and

motorbikes. They continue to make improvements related to quality to meet and maintain customer satisfaction (Utami et al., 2021; Hendra et al., 2021).

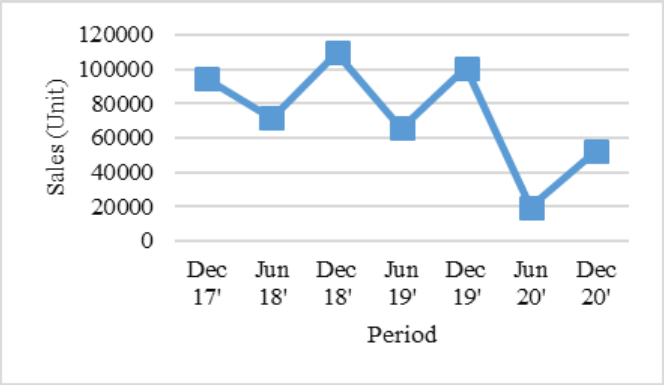

Figure 1. The automotive industry growth trend in Indonesia

Customer satisfaction is the level of customer feelings after comparing what he received and what he expected. Two main factors encourage customer satisfaction, namely as follows: First is product quality, customers are satisfied if, after buying and using the product, it turns out that the product quality is good, and second prices for customers are a sensitive matter. Usually, low prices are an important source of satisfaction because customers will get high value for money. To meet these customer demands, the company needs to carry out quality control activities in the production process (Sreedharan et al., 2018; Ahmadi et al., 2021).

Good quality control will continuously produce products that meet customer standards (Latifah & Rosyidi, 2017; Arif & Abdul, 2019; Vanany et al., 2020). One of the main objectives of the customer specification is to define what is a problem and what is not a problem for the customer (Kurnia et al., 2021). This is very important to build customer trust in the products the company produces so that the company's image will be good. Apart from affecting quality control that meets standards, quality control will also result in lower product prices (Kurnia & Purba, 2021). Because with the reduced number of damaged or defect products, the costs incurred due to defective products will be reduced (Saryanto et al., 2020).

Quality control is an important thing that must be done by companies to minimize defective products. Companies can analyze product defects using the Six Sigma method (Pereiraa et al., 2019). To achieve Six Sigma, it is necessary to take corrective steps using the results of the analysis (Sachin & Dileeplal, 2017). Various strategies have been carried out to win the competition and increase sales, expand market share and reduce production costs.

This study uses references to several studies related to quality improvement by Sambrani (2016); Alshammari et al. (2018); Maryani et al. (2020). In addition, in this study, we also tried to compare with previous studies and with different contexts. Research on quality control, one of which is carried out (Soundararajan & Reddy, 2020). The research was conducted because in the industry there must be a continuous improvement to improve quality. According to Trimarjoko et al. (2019) the approach is to integrate the concept of Lean Six Sigma, Multi-Attribute Failure Mode Analysis, and Fuzzy AHP to identify the causes of potential defects to reduce product defects in production. The results of the analysis show that the independent variable (Potential Defect) has an important role in the production level so it can be seen that quality has an important role. Six Sigma is used as an approach to problems that are happening in a company because in addition to a new flexible management tool, Six Sigma also aims to eliminate production defects (I. Setiawan et al., 2020; Costa et al., 2020). Several previous studies can explain where the quality improvement stage uses the

DMAIC stage. Research by Praharsi et al. (2020); Hernadewita et al. (2019) only focus on improving quality, therefore the focus of this research will be on improving process capability in the manufacturing industry. This study aims to reduce the reject rate and determine the priority of problems in the fuel tank production process.

2. Literature Review

a. Quality

According to Crosby (1979) quality is conformance to requirements, which means that the products produced must comply with established specifications or standards. These quality standards include standards for raw materials, processes and final products. Meanwhile, according to Feigenbaum (1983) quality is full customer satisfaction, namely complete customer satisfaction. A product or service is said to be of high quality if it succeeds in meeting the complete customer satisfaction/ expectations.

b. DMAIC Method

The DMAIC method is a basic series in implementing the Six Sigma approach with various data and statistical-based methods. This method can determine the root of problem-solving (I. Setiawan & Setiawan, 2020). The stages of implementing quality improvement with the Six Sigma approach consist of five steps, namely Measure, Analyze, Improve and Control. DMAIC is a process step for continuous improvement towards 6 Sigma (B. Setiawan et al., 2021). The stages of this method are very structured and complete (Kurnia et al., 2021).

3. Research Method

Section This research was conducted in one of the automotive manufacturing industries in Indonesia. The object of the research is to improve process capability. Research focus on tank fuel products. Data collection is done using observation. The primary data used include daily defective product sampling data, production process flow and direct information from the leadership. While the secondary data used comes from articles in journals, institutional annual reports and company reports. The company's report includes the number of operators, the number of production and production capacity. This study uses a systematic stage of DMAIC. Each stage of DMAIC has an important role to achieve the goal (Trimarjoko et al., 2020). The DMAIC method is a basic series in implementing the Six Sigma approach with various data and statistical-based methods. This method can determine the root of problem-solving (I. Setiawan & Setiawan, 2020). The stages of implementing quality improvement with the Six Sigma approach consist of five steps, namely Measure, Analyze, Improve and Control. DMAIC is a process step for continuous improvement towards 6 Sigma (B. Setiawan et al., 2021). The stages of this method are very structured and complete (Kurnia et al., 2021). The framework of this research can be seen in Figure 2.

a. Define

The stage of defining the problem and translating the production process flow for making fuel tanks. The tools used are SIPOC diagrams and Critical to Quality.

b. Measure

The calculation stage is to determine the sigma level. The calculation method used includes the value of DPO, DPMO and sigma level. The following formula is used at this stage to calculate the sigma value and process capability.

$$DPU = \frac{\text{Total of Defect}}{\text{Total Unit x CTQ Opportunity}} \quad (1)$$

$$DPMO = DPU \times 1{,}000{,}000 \quad (2)$$

$$Cp = \frac{\text{Sigma level}}{3\sigma} \quad (3)$$

c. Analyze

The stage of identifying the causes of problems that cause defective products. The tool used is a fishbone diagram. The results of the fishbone diagram are obtained based on the advice from the experts.

d. Improve

The improvement stage is based on the factors causing the problem. Improvement is done to get a good process to avoid defective products.

e. Control

Controls are carried out to evaluate and provide standards for the process. Then do socialization to workers. The goal is that defective products do not happen again.

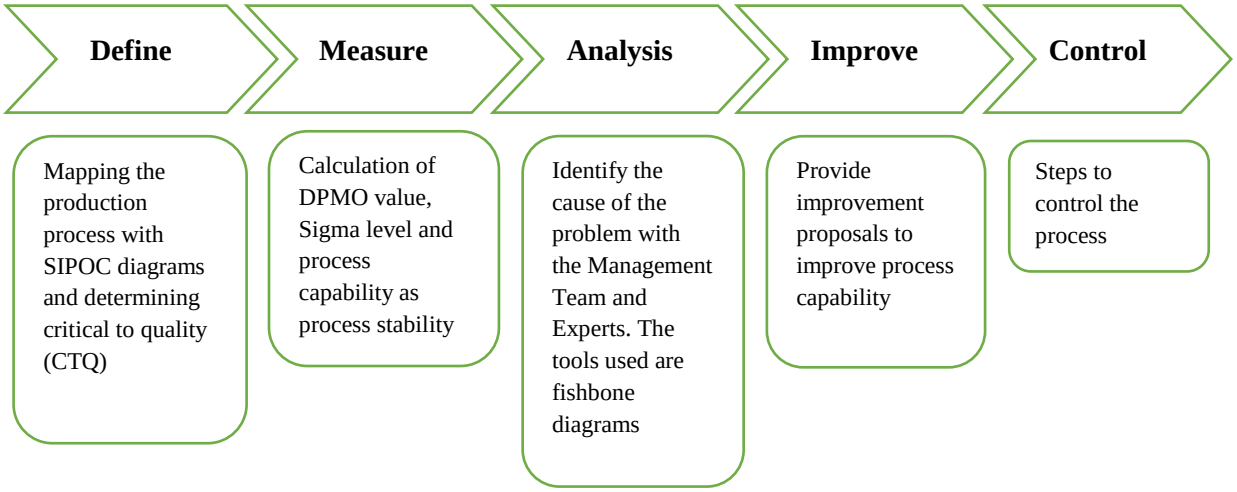

Figure 2. DMAIC framework

4. Results and Discussion

a. Define

At this stage, the production process flow is defined. To define the production flow, this research uses the SIPOC diagram. Figure 3 shows the flow of the production process in the welding and press division. The SIPOC diagram shows that the process starts from the supplier, by the machine and by the vendor. The supplier performs the input process to the welding and press sections. The input from the supplier is in the form of components in the form of Zn or Standpipe in sheet form. Then enter the main process, namely the press and welding process. The output of this process is a fuel tank unit which is a combination of the upper half and the lower half. Then the fuel tank unit will be sent to the customer. Welding fuel tank customers are steel painting workers whose job is to paint the fuel tank unit to make it resistant to corrosion.

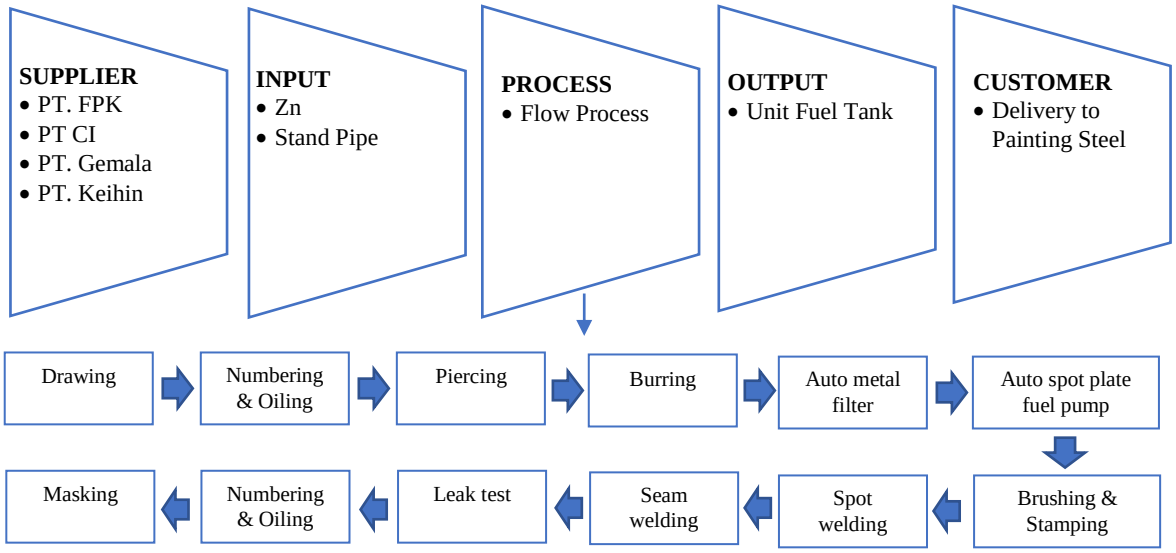

Figure 3. SIPOC diagram of production flow

After defining the production flow, then define the biggest defects in the fuel tank manufacturing process. Defects occur because the products produced do not meet the specifications set by the company. The biggest defect in this process is the Perforated Tank which can be seen in Figure 4. So that an analysis of the causes of the problem and corrective actions will be carried out.

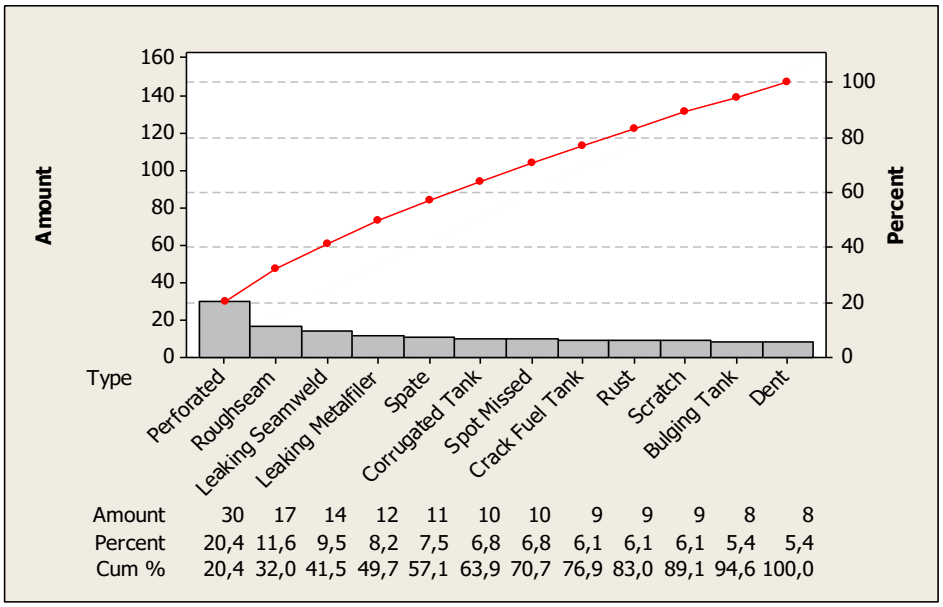

Figure 4. Pareto chart of defect

Figure 4 shows the types of defects that occur in the welding and press processes. The defect will be Critical to Quality (CTQ) The CTQ are the things that most influence the quality of the fuel tank product, for the determination of the CTQ is to analyze the fuel tank defect data, determine which processes have the most influence on the product defect results, and determine the types of defects that have the most influence or produce many defective products.

b. Measure

At this stage, measurements and calculations are carried out to obtain sigma values and baseline capabilities. The formula below shows the DPMO number, Six Sigma value and process capability. The data for calculating the sigma value is taken from Table 1. Data was obtained through samples during field observations.

Table 1. Sample data

No	Sample	Number of Production (units)	Number of Defects
1	1	1,240	127
2	2	1,240	89
3	5	1,240	78
4	6	1,240	119
5	7	1,240	88
6	8	1,240	84
7	9	1,240	77
8	12	1,240	76
9	13	1,240	83
10	14	1,240	76
11	15	1,240	89
12	19	1,240	79
13	20	1,240	78
14	21	1,240	80
15	22	1,240	69
16	23	1,240	73
17	26	1,240	80
18	27	1,240	98
19	28	1,240	76
Totals		23,560	1,619

The calculation at this stage uses the formulas (1), (2) and (3):

$$\text{DPU} = \frac{1{,}619}{23{,}560 \times 12} \times 100\% = 0.005726$$

DPMO = 0.005726 x 1,000,000
= 5,726

Sigma Level convertion = 4.02 σ

$$\text{Index Capability Cp} = \frac{4.02}{3} = 1.34$$

Based on calculations, the company's sigma value is around 4.02 with a capability index value of 1.34. Based on this value, the sigma assessment can be interpreted that the quality control process that has been carried out has not been going well because product defects still occur and must be repaired. Quality control is still needed to increase the obtained sigma value to minimize the possibility of repeated defects. It can still be seen on the U-chart that there are still samples that are out of the control limits. U control chart can be seen in Figure 5.

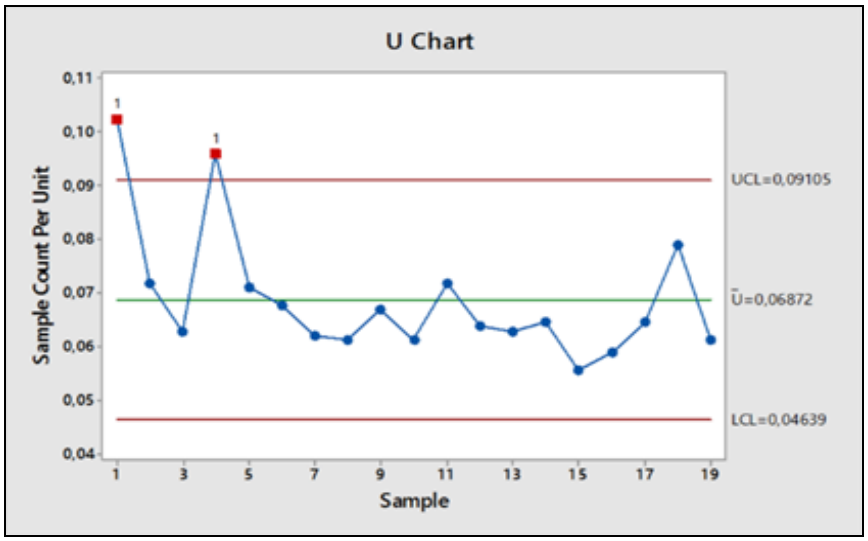

Figure 5. U-Chart of sample defect

Based on the U-chart in Figure 5, there are still several points that are out of control, namely in samples 1 and 6. This is considered an uncontrolled process because two points are outside the center line limit. In sample 1 there are 127 rejected products caused by the auto metal filler process so the repair section is very burdened with the many defects that occur in the metal filler process. In sample 6 there are 119 rejected products that are known to be in the process of leak testing because the fuel tank leaks so the goods must be moved to the repair department. For problem-solving analysis, we use Pareto diagrams. The Pareto diagram uses 90% of the total problem as the priority problem that needs to be solved. Based on Figure 4, the priority problem to be identified is the type of Perforated Tank.

c. Analyze

The next step is to analyze the causative factors of the Perforated Tank defect. The identification stage is carried out by the Management Team and Experts in their fields. This stage uses a fishbone diagram and then defines the root cause analysis. The following analysis of the causes with a fishbone diagram can be seen in Figure 6.

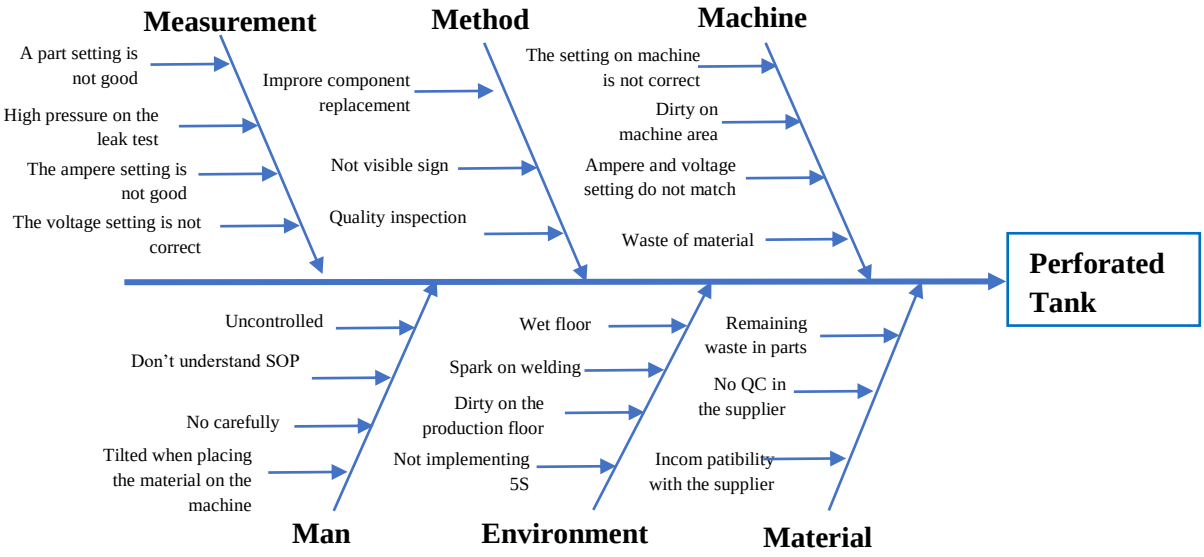

Figure 6. Fishbone diagram of perforated tank

For problem identification, we use cause and effect diagrams. Figure 6 above shows a cause and effect diagram containing the problems that cause the fuel tank bore defects. In Figure 6 there are six main factors, namely human, method, machine, material, measurement and environment. Based on these six main factors, each factor produces a branch of problems such as the inaccuracy experienced by humans (operators) and the amperage and voltmeter settings that are not by the machine's capabilities.

d. Improve

At this stage, a strategic plan is carried out to improve process capability. This improvement plan is only a proposal for process improvement. The following suggestions for improvements made based on suggestions from experts can be seen in Table 2.

Table 2. Strategy of improvement

Process	Type of defect	The causes of the problem	Strategy of improvement
Numbering	The barcode on the fuel tank is not visible	Lots of oil droplets on the workstation	Cleaned regularly
Leak test	Leaking tank	The panel cover is broken & the drains overflow, the start button error, and the cylinder rubber is loose	Repair or remanufacture, clean ducts, and replace sockets
Auto metal filler	Perforated Scratch defects Spate Leaking metal filler	Broken washer lamp, broken wind hose, leaking air hose	Replace busher lights and install pipes
Seam welding	Rough seam Leaking seam weld	Dirty electrodes, overlap	The electrodes must be cleaned periodically, the operator must be more focused
Auto Spot plate fuel pump	Spot missed Scratch defects Spark defect	Incorrect part position and incorrect engine pressure	Check the position of the part and the JIG must be checked
Spot welding	Scratch defects	The position of the part or material is not right	Operators must follow established procedures
Supplier	Rust / defects	There is no QC from the supplier	That should be for communication with suppliers regarding material quality
Amino machine Aida machine	Dent Swelled tank corrugated tank crack / broken	There is dirt on the die & material, the pressure is not appropriate, the robot vacuum arm is loose due to a broken fastener bolt, the power cable is messy, and the scrap disposal is dirty	Cleaned regularly, reduce pressure from 170 to 190, cables are tied and trimmed

e. **Control**

This section controls the improvement strategies carried out. First, create a Standard Operating Procedure (SOP) to standardize the process. Then socialize to all workers to provide understanding and knowledge of the latest standards. The U control chart is used to control the process.

f. Discussion

The improvement strategy in this research is just a suggestion given by the project team. The recommended fixes are not fully verified. So it becomes a limitation in the research. The results of this study provide information that the process capability in welding and press production is still not

capable. The improvements made are expected to increase the capability process in the production chain.

This research provides specialized knowledge in the automotive manufacturing industry in planning and controlling quality through process capabilities. The results of this study are in line with research of Maryani et al. (2020) that to improve process capability, control and improvement of the production process must be carried out on an ongoing basis and there must be support from top management.

5. Conclusion

The This study aims to improve the capability of the fuel tank production process. Based on the analysis in the previous stage, it can be concluded that the company's sigma level in the welding & press section obtained a sigma value of 4.02 with a process capability value of 1.34. This means that the quality control process that has been carried out has not been going well because product defects still occur. Based on the improvements made, it is expected that the capability of the welding and press processes will increase. This study has limitations on the lack of maintenance on the machining process so further research is recommended to improve the process capability by analyzing the machine maintenance factor through Total Productive Maintenance (TPM).

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