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Analysis of Product Defects in Stay Horn Parts during the Welding Process Using Fault Tree Analysis (FTA) and Failure Mode and Effects Analysis (FMEA)

Muhammad Kholil

Industrial Engineering Department

Faculty of Engineering

Universitas Mercu Buana

Indonesia

ABSTRACT

The company in this study is an automotive company that produces, among other things, stay horn parts. The issue faced by the company is that the defect rate in stay horn parts exceeds the standard, with a defect rate of 2.06%, while the company's standard is set at 1%. This study aims to identify the highest cause of defects, determine the Risk Priority Number (RPN), and provide improvement suggestions to reduce the defect rate to meet the company's established standards. The methods used for this research are Fault Tree Analysis (FTA) and Failure Mode and Effect Analysis (FMEA).

Keywords*:* Fault Tree Analysis (FTA), Failure Mode and Effect Analysis (FMEA), Risk Priority Number (RPN).

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1. INTRODUCTION

Quality is a dynamic condition related to products, services, people, processes, and environments that meet or exceed expectations. Product defect improvements are carried out in each production cycle to maintain the quality produced and ensure customer satisfaction with the company's products. To achieve the desired product quality and standards required by the market, the company must focus on its production process to remain effective and efficient. The company must implement good quality control to avoid potential losses during production, such as deteriorating material quality and additional costs for reworking defective products (Haekal, 2022).

Quality issues are one of the most important aspects that require serious attention to remain competitive. This involves developing better, more sophisticated, higher-quality, and cheaper products compared to previous ones, especially given the rapid technological changes. Companies are also required to excel in competitiveness and quality (Rosid, H., 2019). A defect is a component that does not fall within customer specifications. Every step or activity within a company is an opportunity for defects to occur. Defects are also considered a form of waste, representing activities or elements that do not add value and incur additional costs in the production process, thereby reducing product competitiveness. Defects can result from several factors, including employee errors, the materials used, equipment usage, and other factors.

A company can be said to produce quality products if it has a good production management system and a controlled process. By implementing quality control, a company can increase productivity and efficiency by preventing defective products, reducing waste both in terms of raw material usage and the time required to produce a single unit.

An automotive manufacturing industry, of course, cannot stand alone when producing the small components needed for automotive products. In fulfilling its function as an integral part of the automotive industry, the company requires suppliers to provide various components, which are then assembled into the final automotive product. One of the products produced by the company is the stay horn part.

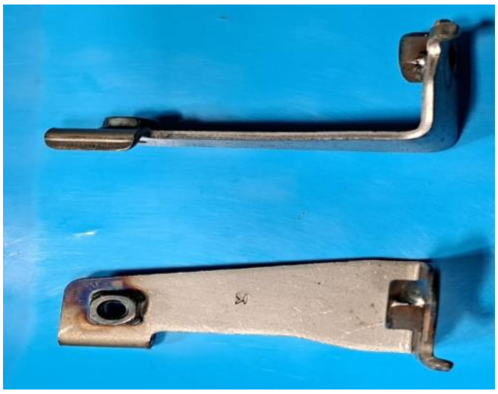

Figure 1 Part Stay Horn

From Figure 1 above, one of the production process results is the Part Stay Horn. The Part Stay Horn is the horn bracket frame on a motorcycle, made of metal. During the manufacturing process, there is an issue with the welding, which is performed by manual labor. This causes the product to not meet the company's standardization according to the rules and policies, thus significantly impacting the quality of the final product. According to the data obtained after observation, the researcher found that the product did not meet the company's standards, resulting in defective products. The types of defective products include the Part Stay Horn, Stay Comp Fuel Hose, Stay L CTR Side, Stay R Fuel Tank, and Stay Comp Fuel Hose K60.

Based on data from the company's production department, the production data for the Part Stay Horn from January to June 2022 shows that the defect rate exceeded the company's standard defect limit of 1%. The defects were caused by failures in the welding process or spatter, resulting in products that did not meet the company's standards, and consequently, the quality of the products declined due to lapses in final product inspection. Therefore, further research is needed to identify the causes of defects in the Part Stay Horn product, which is used in motor vehicles. Thus, further research will be conducted to assist the company in determining the highest contributing factors to the defects in this product. The Fault Tree Analysis (FTA) method can be used to detect symptoms and identify the root causes of a problem. Meanwhile, the Failure Mode and Effect Analysis (FMEA) method can identify product failures or defects, evaluate the effects of these failures, and prioritize them based on the severity of their impacts (kholil et al 2023).

2. METHOD

The data collected for processing follows these steps:

1. Identification of Defects Identify the types of defects occurring in the Part Stay Horn product over six months.
2. Determining the Sources of Defects Conduct an in-depth search for the potential sources of the identified defects.
3. Fault Tree Analysis (FTA) Method Steps to create a Fault Tree Analysis (FTA):
   a. Identify the most significant events.
   b. Establish the boundaries of the Fault Tree Analysis (FTA).
   c. Test the system to understand how different elements relate to each other and the top events.
   d. Create a fault tree, starting from the top-level events.
   e. Analyze the fault tree to identify ways to eliminate events that cause failures.
   f. Develop a corrective action plan to avoid failures.
4. Failure Mode and Effect Analysis (FMEA) Method Steps to create a Failure Mode and Effect Analysis (FMEA):
   a. Determine the levels of severity, occurrence, and detection.
      - Severity: The level of severity or impact of failure conditions on the entire machine. The severity rating ranges from 1 to 10 (the higher the severity, the greater the impact).
      - Occurrence: The frequency of damage or defects. This refers to the estimated cumulative number of failures in the machine for specific reasons to determine the likely causes of failure based on error

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conditions, assigning a rating. The occurrence rating ranges from 1 to 10 (the higher the frequency, the more likely the process will fail).

- Detection: The effectiveness of the current control system in detecting the causes or modes of failure. The detection rating ranges from 1 to 10 (the higher the detection number, the lower the confidence in detecting errors in the process).

b. Calculate and classify the Risk Priority Number (RPN).

c. Perform inspections and suggest improvements using the 5W + 1H method.

5. Providing Improvement Suggestions Offer recommendations to reduce defects in the Part Stay Horn product.

3. RESULTS AND DISCUSSION

In this section, we discuss the results and analysis of determining the most dominant failure improvements. To solve this problem, we use Pareto diagrams, fishbone diagrams, fault tree analysis (FTA), and failure mode and effect analysis (FMEA). Below is the analysis of the processed data.

3.1 Results and Discussion of Defect Data Using Pareto Diagram

The data processing using the Pareto diagram helps determine the types of defects that occur and the percentage of each defect type in the part stay horn product. There are 4 types of defects in the part stay horn product: spatter defect at 2.06%, tight nut at 1.76%, burn-through welding at 1.26%, and porous welding at 1.23%. From these percentages, it can be determined that the largest defect is spatter, reaching 2.06%, making it the top priority for improvement.

3.2 Results and Discussion Using Fault Tree Analysis (FTA)

The spatter defect in the part stay horn product at PT Nandya Karya Perkasa is caused by several factors such as man, machine, method, material, and environment. Here are explanations for each of these factors:

1. Man Factor
   - Non-compliance with SOP
     - Lack of adherence to standard operating procedures by operators during production due to insufficient attention to SOPs.
     - Lack of supervision during production, leading to a lack of discipline among operators.
   - Lack of Accuracy
     - Insufficient regular checks by operators, leading to carelessness and subpar quality.
   - Inadequate Training
     - Operators lack periodic or continuous training, resulting in inexperienced operators not receiving proper training from more experienced ones.
2. Machine Factor
   - High Amperage
     - Amperage setting discrepancies lead to high amperage, deviating from the company's SOP.
   - Damp Electrodes
     - Improper electrode storage causes dampness, affecting machine performance.
3. Method Factor
   - High Travel Speed
     - Excessive speed during operations due to rushing, without proper speed checks.
   - Electrode Distance from Base Metal
     - Lack of standardization for electrode distance from the base metal, leading to defects.
4. Environmental Factor
   - Inadequate Lighting and Humidity
     - Poor lighting and inappropriate humidity levels in the welding area affect product quality.
5. Material Factor
   - Non-conforming Materials
     - Materials not meeting company specifications lead to defects.

3.3 Results and Discussion Using Failure Mode and Effect Analysis (FMEA)

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After identifying the main causes of the spatter defect in the part stay horn product, FMEA identified three highest RPN (Risk Priority Number) ratings. Here are the results:

1. Lack of Accuracy in Welding Process
   - The highest RPN rating of 448 is due to human factors (Man). The main cause is the lack of operator training, leading to operator negligence during tasks.
2. Non-compliance with SOP by Employees
   - The second highest RPN rating of 294 is due to human factors (Man). This is caused by insufficient supervision, leading to potential spatter defects.
3. Damp Electrodes
   - The third highest RPN rating of 252 is due to machine factors (Machine). This is caused by improper electrode storage, leading to unstable welding.

3.4 Improvement Proposals Using 5W+1H

Based on the analysis results using fault tree analysis (FTA) and the calculation of the risk priority number (RPN) from the failure mode and effect analysis (FMEA) on the processed data, several potential causative factors will be prioritized for improvement proposals to reduce the number of defects in the part stay horn product. After the analysis results identified the root causes from interviews with supervisors, improvement proposals will be made using the 5W+1H method.

ased on the 5W+1H analysis of spatter defects and their causative factors in the part stay horn product, the following improvement proposals have been identified:

a. The first improvement proposal for spatter defects is to provide training to each operator, including both theoretical and practical aspects of the welding process, according to the company's established guidelines. The purpose of conducting training is to enhance the operators' skills and knowledge.

b. The second improvement proposal for spatter defects is to conduct briefings before and after work to share information about production results and any challenges faced by operators during the welding process.

In an effort to reduce spatter defects in the part stay horn product and improve production quality, continuous improvements must be made to achieve high quality and prevent the recurrence of causative factors.

4. CONCLUSION

Based on the analysis results, the conclusions obtained are as follows:

1. Based on the analysis using a Pareto chart, four types of highest defects in the Part Stay Horn product were identified: spatter defects, rough threads, burn-through welding, and porous welding. The highest defect type is spatter, accounting for 33%. Further analysis was conducted to determine the causes of defects using a fishbone diagram. The identified causes are due to human factors (man), method factors (method), machine factors (machine), environmental factors (environment), and material factors (material).
2. From the calculations using the Failure Mode and Effect Analysis (FMEA) method, the types of failures prioritized for improvement were determined by the Risk Priority Number (RPN). The highest RPN value was attributed to human factors, specifically lack of attention during the welding process, with a top value of 448, and employee performance not adhering to SOPs, with a value of 294.
3. Therefore, to reduce the number of defects in the Part Stay Horn product, improvements will be implemented by providing the following suggestions. The first improvement suggestion is to provide training for each operator, including theoretical and practical aspects of the welding process as determined by the company. The second suggestion is to conduct briefings before and after work.

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Email: muhammad_kholil@mercubuana.ac.id

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