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Quality Control with Failure Mode and Effect Analysis (FMEA) And Fault Tree Analysis (FTA) Methods: Case Study Japanese Multinational Automotive Corporation

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ABSTRACT
Automotive Company is one of the manufacturing companies engaged in the automotive sector. This automotive company produces products for two-wheeled vehicles and four-wheeled vehicles. Based on the researchers' data from January 2021 to May 2021, currently, the line site body has problems related to quality. During the production process, some products do not meet specifications and cause damage to the product. Research conducted at this automotive company found four types of defects: dents with a percentage of 52.48%, sharp spots with a percentage of 20.79%, stray spots with a percentage of 19.80%, and rust with a percentage of 6.93%. Two tools can assist quality control, namely the Failure Mode and Effect Analysis and the Fault Tree Analysis. From the research, an analysis of the causes of defects from all types of defects is given suggestions for improvements to the analysis. The results showed that the cause of the defect was dominated by operator error, namely not being careful in checking, not carrying out the work process properly and method factors, namely lack training for new operators and transfers to carry out work in the welding section.

Keywords: Automotive Company; Quality; FMEA; FTA

INTRODUCTION

Automotive is one of the industries affected by the Covid-19 pandemic. The national automotive industry has felt the impact of the Covid-19 outbreak. The pandemic is still ongoing. The automotive industry is starting to rise slowly, where car sales in the country are wholesalers (factories to dealers) in September 2020, the most since last April when the Covid-19 pandemic began to hit.Looking at data from the Association of Indonesian Automotive Industries (GAIKINDO), car sales in September rose 30.2 per cent compared to August. In April, direct sales fell to only 7,868 units and even more alarming in May to 3,551 units. Car sales in Indonesia gradually recovered in May, namely 12,623, then July 25,283, August rose again to 37,277, and September became the highest during the Covid-19 pandemic at 48,554 units. But years have passed, and the pandemic is a challenge that must be faced together.

Automotive companies have spread across Indonesia, one of which is in Bekasi Regency, engaged in car manufacturing. The factories are spread in 3 locations, namely Cakung, Tambun and GIIC Cikarang. One of them is an Automotive Company with branches in Tambun Area. This company produces several types of products for domestic and export needs. This company has a fairly wide distribution. The products made by this company not only meet the domestic market but have penetrated the international market. The company has been exporting to countries in Asia, Africa, and Europe. Therefore, quality is an important factor in maintaining consumer loyalty and competitiveness. With a fairly large distribution, it must have quality standards in its production.

Entering 2021, the increase in production began to increase. This also affects the quality of the product itself. However, obstacles in achieving the optimal amount of production and conformity with the specifications required by consumers become an obstacle for the factory in producing it. Defects are still being discovered by the Quality team, starting from dents, sharp spots, and rust, which several factors can cause. There are various deviations in the production process, from machines, raw materials, use of tools / JIG, work environment, methods used and human error (errors made by humans/workers). This indicates that in the process of PT. This automotive company is still experiencing many shortcomings in terms of quality. The quality management system only emphasizes continuous improvement efforts. They are based on the self-awareness of management without providing a powerful solution in terms of breakthroughs that must be made to improve quality towards the point of zero defects dramatically. According to [1-24] quality control is one factor that can determine success or failure. The good or bad of a product will be identified by the existence of control activities that improve the quality of the product produced. Companies engaged in production process activities must continue to pay attention to quality control activities. In general, the purpose of research activities on quality control issues is to provide an overview of a good method for the production process and identify the factors causing the emergence of defective products or products that are not suitable. This is based on the consideration that many companies do not pay attention to defective products, meaning they are aware of defective products. Still, there is no follow-up from the management. The company tries to prevent out of control events so that the same thing doesn't happen again in the future. The company's management usually only takes temporary precautions, while problems will continue to exist in a company.

To take preventive and corrective actions, it is necessary to cooperate with all parties involved in the company's organizational structure on an ongoing basis. Based on the data that the author got from January 2021 to May 2021, at this time, this Automotive Company has problems related to quality, namely in the Site body line.

Therefore, in this defect problem, it is necessary to make improvements to optimize the quality of car production. The following data on the number of products and types of Site Body product defects from January 2021 to May 2021 can be seen in Table 1 below.

TABLE 1: Data on Total Production and Types of Product Defects at Site Body from January to May 2021

Month	Number of Production (Units)	Defect Type				number of defects
		dent	Sharp spot	Rust	Stray Spots	
January	735	11	3	1	1	16
February	735	8	2	-	2	12
March	735	11	2	2	4	19
April	735	10	8	1	5	24
May	735	13	6	3	8	30
Total	3.675	53	21	7	20	101

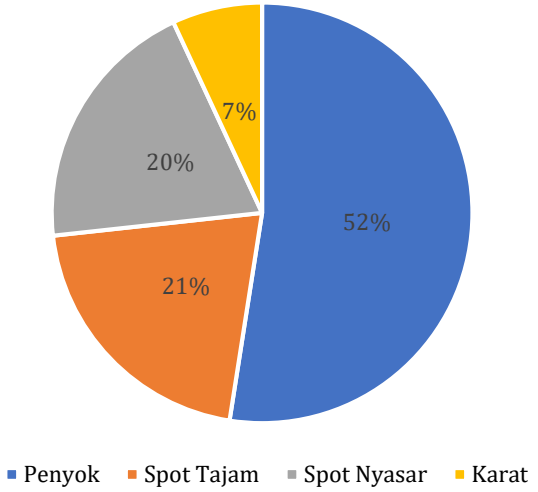

FIGURE 1: Percentage of Product Defect Types

The table above shows that the Site Body has the most dominant defect among other defects, with the type of defect being dented. The company applies product quality standards, namely zero defects. Therefore, it is necessary to propose quality improvements to reduce or reduce the level of defects in the site body process, the Failure Mode and Effects Analysis (FMEA) method, which is a tool to help provide suggestions for improvements to the production process to improve the quality of the products produced. By applying the proposed improvements that have been made, it is expected to reduce the level of defects that occur. The Fault Tree Analysis (FTA) method is used to identify and find the causes of failures in the production process that cause product defects. For this purpose, in this study, an analysis of the defect was carried out to determine the cause of the defect in the site body process using the FMEA (Failure Mode and Effect Analysis) and FTA (Fault Tree Analysis) methods.

RESEARCH METHODOLOGY

The table above shows that the Site Body has the most dominant defect among other defects, with the type of defect being dented. The company applies product quality standards, namely zero defects. Therefore, it is necessary to propose quality improvements to reduce or reduce the level of defects in the site body process, the Failure Mode and Effects Analysis (FMEA) method, which is a tool to help provide suggestions for improvements to the production process to improve the quality of the products produced. By applying the proposed improvements that have been made, it is expected to reduce the level of defects that occur. The Fault Tree Analysis (FTA) method is used to identify and find the causes of failures in the data collection method.

(1) Data Collection Method

The method of collecting data or information used by the author is as follows:

- Observational Study

Observation is a method of collecting data by directly observing the phenomena and conditions of the area that is the object of the research. And carried out several discussions directly with workers in the field directly related to the object of research, such as the Leader of the site body section. With the observation, it will be easier to know the conditions at the research site to get valid data.

- Interview (Interview)

Interview (Interview) is a data collection technique carried out through face-to-face and direct questions and answers between data collectors and researchers to informants or data sources. This research conducts questions and answers directly to the object of research through interviews with people who represent this company to the production operator at the Site body Mr Edi, Mr Hendro Haryanto as the site body production leader and Mr Isfaudin as Quality Control by asking several questions aimed at to find problems more openly and clearly.

- Documentation

Collecting data by recording or duplicating historical company data by research needs and the problems studied.

TABLE 2: Table of types of defects

No	Defect Type	Figure of Defects
1	dent	
2	Stray Spots	
3	Sharp Spot	
4	Rust	

(2) Methods of Data Processing and Analysis

Data processing in this study was carried out by identifying the types of raw materials that often-experienced inventory discrepancies using Pareto diagrams, analyzing the factors causing inventory discrepancies in stock-taking activities using Fishbone diagrams, and designing improvement proposals using the Failure Mode and Effect Analysis (FMEA) method. And Fault Tree Analysis (FTA) as follows:

- Identification of defects that occur Identify the types of defects that occur in the Site body during the period January - May 2021

- Create a Pareto chart

A Pareto diagram is a diagram that is used to determine the cause of the problem with the effect that occurs. With this diagram, it can be seen the causes of defects that make the dominant effect of a defect. The results of the Pareto diagram are analyzed to determine the source of the defect's because that makes the defect's dominant occurrence so that a repair plan can be carried out.

- Fishbone Diagram

Fishbone Diagram or commonly called Cause-and-Effect Diagram is a tool to identify various potential causes of an effect or problem and analyze the problem through brainstorming sessions. Problems will be broken down into several related categories, including people, materials, machines, procedures, policies, etc. Each category has causes that need to be explained through a brainstorming session.

- Failure Mode and Effect Analysis (FMEA)

From the data processing that has been carried out, an analysis of the potential causes of failure and priority of repairs must be made to make recommendations/proposed improvements to prevent inventory discrepancies using the Failure Modes and Effects Analysis (FMEA) method. The stages carried out are:

(a) Write down Failure Mode and Failure Effect

After knowing the causative factors obtained from identifying the Fishbone Diagram, it is then used as input into the FMEA table to be further described in more detail for each process.

(b) Severity

It is a ranking of sources of problems based on the impact of the risk that occurs. This rating is based on 1-10, with a score of 10 as the risk effect caused is of high value.

(c) Occurrence

This is the stage after determining Severity. At this stage, the source of the problem that has determined the level of risk is an assessment of how often the problem occurs. The rating value is 1-10, with level 10 being the highest occurrence rate.

(d) Detection

At this stage, the source of the problem is assessed based on the level of detection that has occurred so far, whether the source of the problem is easy to detect or difficult to detect. Rating value between 1-10. A value of 10 results from detection that can't be done at all.

(e) Risk Priority Number (RPN)
Risk Priority Number (RPN) results from Severity x Occurrence x Detection. The largest RPN value results from the highest risk priority value, while the smallest RPN is the result of the lowest risk priority. After all the RPN results are obtained, the RPN is sorted from largest to smallest.

- Fault Tree Analysis (FTA)

The source of the cause of the defect has been obtained; then, an FTA is carried out to find a relationship between the input on the source of the cause of the defect and the output on the type of defect that occurs. The FTA output or the top of the problem tree is derived from the type of defects that occur, and the FTA inputs or tree-like branches are the sources of the defects. Analysis needs to be carried out to ensure that the occurrence of defects that occur due to the source of the defect originating from the root of the problem tree branch so that the next data processing does not become wrong due to an error in determining the source of the cause of the defect.

- Results and Discussion

At this stage, recommendations for improvement are made based on an analysis of the problems that exist in the Line Site body to overcome the problems that occur and take corrective actions to prevent the problem from recurring.

- Conclusion and Suggestions

At this stage, conclusions and suggestions are drawn, which is the final stage of this research. The conclusion is the answer to the research objective, while the suggestion is to be shown to further research related to similar research that may be carried out.

RESULT AND DISCUSSION

(1) Identification of Types of Defects

- Based on the pie chart

Based on the pie chart, it can be seen that the total site body defect data for the five months in January 2021 - May 2021 reached 3% of the total production.

- Based on the results of the Pareto diagram analysis

Based on the results of the analysis of the Pareto chart, it can be concluded that there are four defects in the Site Body that occurred during five months in January 2021 - to May 2021, including the following:

(a) Dent with a percentage of 52.48%
(b) Sharp spot with a percentage of 20.79%
(c) Spot stray with a percentage of 19.80%
(d) Rust with a percentage of 6.93%

The type of defect is then identified as the failure mode or failures that occur during the welding process at the line site body for further analysis using the Failure Mode and Effect Analysis (FMEA) method.

(2) FMEA Analysis Results

Based on the Failure Mode and Effect Analysis (FMEA) analysis results, the Risk Priority Number (RPN) value was obtained. The RPN value determines which failure mode has the highest risk. The following are the results of the FMEA analysis of each failure mode, including:

- Dent

(a) Based on the results of the FMEA analysis of the failure mode of the human factor, namely Human error (passing check), which has the largest RPN value of 120 passing the check, this has an impact on the production operator not being careful in checking the material to be used, so it is considered part ok.

(b) based on the results of the FMEA analysis of the failure mode of the method factor, namely, there is no written work instruction sheet on the line site body; it has an RPN value of 105. i.e. no written work instruction sheet on the line site body affects the operator to be less understanding of work instructions.

(c) Based on the results of the FMEA analysis, the failure mode of the method factor, which is not neatly arranged on the shelf, has an RPN value of 36, which is not neatly arranged on the shelf, resulting in dents because the Production Support Operator puts it on the shelf as is.

- Sharp Spot

(a) Based on the results of the FMEA analysis, the failure mode of the human factor, namely decreased concentration, has an RPN value of 96 because of decreased concentration which causes operators to experience fatigue and pursue targets.

(b) Based on the results of the FMEA analysis, the failure mode of the method factor, namely not carrying out the work instruction sheet, has an RPN value of 60 because not carrying out LIK (work instruction sheet) has an impact on the operator not understanding the position of spot welding which should be done upright. Still, the operator in welding is not upright. Straight with the material.

- Stray spots

(a) Based on the results of the FMEA analysis, the failure mode of the human factor, namely the improper welding technique, has an RPN value of 120 because the improper welding technique impacts the performance and experience of the operator in lack of training.

(b) Based on the results of the FMEA analysis, the failure mode of the human factor, namely not seeing the position of the spot points, has an RPN value of 84 because it has an impact on results and quality because the target will not be right in taking part of the point to be in a spot.

(c) Based on the results of the FMEA analysis, the failure mode of the method factor, namely not carrying out LIK (Work Instruction Sheet), has an RPN value of 96 because not carrying out LIK (Work Instruction Sheet) has an impact on welding not in the order determined by the company.

- Rust

(a) Based on the results of the FMEA analysis of the human factor failure mode, the production operator is less careful in picking and selecting the parts to be used, and has an RPN value of 36 because this causes the operator not to detect rust.

(b) Based on the results of the FMEA analysis, the failure mode of the method factor, namely the planning mismatch between pressing and welding production, has an RPN value of 48 because storage inline storage for too long can cause rust.

Based on the results of the FMEA analysis above, then it is processed in a Pareto diagram to get the RPN value from the highest and lowest. And then analyzed using the FTA (Fault Tree Analysis) method of each defect.

(3) RPN Highest Rated Recap

The highest RPN values that have been carried out based on analysis with FMEA are as follows.

TABLE 3: recap of the highest RPN

No	Type of defect	Reason	RPN
1	dent	Production operators are not careful in checking the material to be used	120
2	Stray	Lack of training	120
3	dent	Operators do not understand work instructions	105
4	Sharp spot	Spot results have scrap	96
5	stray spot	Welding is not in order	96

Based on Table 3 data processing that has been carried out using FMEA, the results obtained based on the Pareto diagram can be seen that the highest value is up to 80% of the total problems, including Operators are not careful in checking 120, Lack of training is 120, Operators do not understand work instructions by 105, the spot results have a scrap of 96, and welding is not in the order of 96. The five causes of site body defects get the highest RPN value because they have a major failure rate, and the main cause is in the line site body. The five causes of failure are the occurrence of the failure mode from human factors (operators) and method factors.

(4) Results of FTA Analysis

After determining the failure mode of each defect, then the cause of failure mode or the cause of the failure mode is analyzed with FTA as a Top event to trace the root cause of the problem so that the basic cause (Basic event) is known, namely:

- Defect dent (Top event)

(a) The human factor is the production operator is not careful in checking the material. The human factor is one factor that plays an active role because humans are actors in this case, operators. This can be influenced by several reasons, namely the production operator is not careful in checking the material due to working in a hurry. this is due to Chasing the target.

(b) The method factor is the lack of understanding of work instructions. This is influenced by several reasons: disobeying work procedures and operators ignoring work regulations.

- Sharp spot defect (Top event)

(a) The human factor is that the spot results have a scrap. This is because the welding by the operator is not perpendicular which is caused. After all, the operator is tired and works continuously to meet the target.

(b) The method factor is that the welding position is not perpendicular; this is because the operator does not understand how to hold the spot gun properly, which is because the operator does not understand the instructions from the leader due to low operator performance.

- Stray spot defects (Top event)

(a) The human factor is that the target is not right in taking part of the point that will be in a spot. This is because the operator is not focused on pursuing the target due to a rush.

(b) The method factor is the lack of training caused by OJT, the training period for new employees is not long, and transfer and replacement operators are not trained beforehand.

(c) The method factor is that the welding is not in order. This is because employees do not try to implement existing SOPs due to a lack of supervision and lack of direction by the leader.

- Rust defect (Top Event)

(a) Human factor, namely the operator did not detect the presence of rust due to rust not being visible to the operator caused by small rust carvings.

(b) The method factor is storage in Line storage that is too long due to safety stock which is due to avoid damage to the pressing machine and the varying amount of welding production because production demand often fluctuates.

(5) PROPOSED IMPROVEMENTS

The suggestions for improvement that can be made based on the FTA analysis are as follows.

TABLE 4: Proposed improvements

No	Type of defect	Failure mode	Reason	Cause of failure	Suggestions for improvement
1	dent	Man	Dent Human Error Part (Pass Check)	Production operators are not careful in checking the material to be used	the leader gives directions to the operator to check before welding

No	Type of defect	Failure mode	Reason	Cause of failure	Suggestions for improvement
2	Stray	Method	Welding technique is not right	Lack of training	• Conducting a briefing before starting work so that creative ideas for improvement can be conveyed.
3	dent	Method	There is no written work instruction sheet on the line site body	Operators do not understand work instructions	• Conducted skill training or OJT training on understanding new employees or transfer employees and OJT on line for one month supervised by the leader before being released to the production line
4	Sharp spot	Man	Concentration Decrease	Spot results have scrap	• An information board is made and a work instruction sheet is attached to the line site body so that the operator understands in case of repeated errors
5	stray spot	Method	Not running LIK (Work Instruction Sheet)	Welding Not in order	• Conducting a briefing before starting work, the goal is to build positive thoughts both for yourself and for colleagues. • A sample part board is made and attached to the welding procedure according to the order according to ISOS (Indo Mobil Suzuki operation standard)
6	stray spot	Man	Do not see the position of the spot point	The target is not right in taking part of the point to be spot	• Conducting a briefing before starting on quality in order to build positive thoughts for both yourself and colleagues so that the operator's awareness of quality can increase • Held skills training or training on understanding for new employees or transfer employees before being released on the production line • Make a sample board for any areas that are spot on the part.

Suggested fixes for sharp Spots and stray spots:

(a) The occurrence of sharp spot defects and stray spots is due to method factors that do not understand the spot area and lack of knowledge of SOPs in welding. This can be detrimental to the company regarding cost and product completion time. The company only makes repairs if there is damage to the product; it is proposed to create boards or simple products that have been cut so that the product area looks neat and clear. The sample board can be seen in Figure 2 as follows:

FIGURE 2: Spot point area sample board

(b) Proposed improvements to lack of understanding of welding SOPs and knowledge of the correct spot sequence instructions, an information board regarding quality is made, which can be seen in Figure 3 as follows:

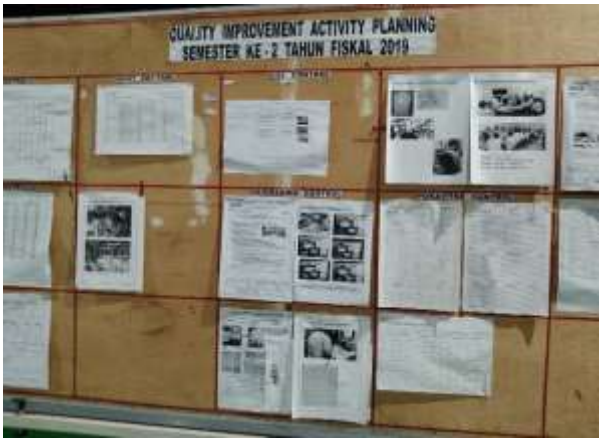

FIGURE 3: Quality information board

CONCLUSION

Based on the results of research and data analysis that has been done, it can be concluded:

(1) There are four types of defects found in the site body process: dents, sharp spots, stray spots, and rust. Dent types with 52.48%, sharp spots with a percentage of 20.79%, stray spots with a percentage of 19.80% and karats with a percentage of 6.93%.

(2) Based on the analysis that has been carried out using Failure Mode and Effect Analysis (FMEA), the factors causing the defect are dents, sharp spots, stray spots and rust. It is known that two factors cause the defect, namely operator error and method error, namely:

(a) Dent defect
- Operator error factor is the production operator. Not careful in checking the material used.
- The method factor is that the operator does not understand the work instructions, and the Production Support operator puts it on the shelf.

(b) Sharp spot defect
- The human factor is the result of the spot there is scrap.

(c) The method factor is the spot-welding position is not perpendicular to the stray spot defect material
- The human factor is lack of training, and the target is not right in taking part of the point that will be in a spot.
- The method factor is Welding Out of order.

(d) Rust defects
- The human factor is the operator does not detect the presence of rust.
- Method factor is stored inline storage that is too long.

(3) Based on the analysis results from the Fault Tree Analysis, the general suggestions for improvements that can be made to improve the operator factor and method factors for dented defects, sharp spots, stray spots and rust are as follows:

(a) Proposed improvements that the company can make are conducting OJT before being placed in the work line with the leader's supervision and conducting skill training or training on understanding for new employees or transfer employees so that operator skills can improve before being placed on the line.

(b) Proposed improvements to the lack of understanding of SOPs by making information boards in each line and attaching work instruction sheets regarding welding understanding and SOP sheets regarding work rules so that operators can read and understand them.

(c) Suggestions for improvement are making a special information board for sample spot points on each part of the body to understand when making a mistake and can be applied after making a mistake.

SUGGESTION

(1) Improvement and training for employees, especially new employees, so that the performance or performance of the process can be increased and can reduce defects. This is based on the number of errors caused by the man factor.

(2) The company is expected to increase the strict supervision carried out by the QC section and the leader of each line to reduce product defects.

(3) Improve the implementation of SOP (Standard Operating Procedure) in the production environment so that all employees can understand the existing rules.

(4) It is hoped that further research can discuss other methods that are still related to more widespread improvements and relevant to future conditions.

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