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Integration of Fmea in the Application of Quality Control Circle (QCC) for Quality Improvement of Production Process in Pipe Bender Machines

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Abstract
This research aims to improve the quality of the production process on the Pipe Bender machine at PT XYZ through the integration of Failure Mode and Effect Analysis (FMEA) in the Quality Control Circle (QCC). The initial analysis identified a major problem in the form of damage to the wiper components that caused the product defect. The main causes include materials that are too hard, lack of spare stock, and the absence of standard wiper radius specifications. The solutions implemented include changes in the technical specifications of wipers, the manufacture of stock control systems, and the standardization of production processes. The results of the evaluation showed a 50% reduction in the frequency of damage, from a total of 17 problems to 8 problems, and an increase in production efficiency. The QCC-based approach has proven to be effective in improving the performance of the production process in a sustainable manner.

Keywords: FMEA,QCC,Improvement.

Introduction

PT XYZ is an automotive and non-automotive component manufacturing company. Its products include automotive parts and industrial equipment such as generators. PT XYZ has 246 machines to support its operations. The switching process at PT XYZ still occurs when there are components that fail so that they interfere with the production process (Nisfi, 2019). At PT XYZ there is a Pipe Bender machine that is used to fold or bend plates. The main problem that occurs is aimed at eliminating repeated problems in the process of bending the pipe roll miff siha. PT XYZ was established in 2001 as a major production of automotive components. Some of the main customers are PT AHM, Kayaba, PT Chemco, PT Yutaka, Hitachi, PT Astra Otoparts, Isuzu, Toyota, Honda, Hino, PT Yanmar, PT Dein. Efforts to increase the company's productivity in catering to its customers are by always paying attention to product quality.

The production process that is carried out by paying attention to and meeting quality standards is able to reduce the number of defective products. This allows production activities to run without experiencing damage to the product (Windarti, 2014). Thus, companies can minimize production cost waste due to defects and increase efficiency in their production process (Yudi, Milenia, 2021). Dapartement Engineering at PT XYZ has found the core of the problem that occurred, one of which is in the bending roll process machine. The problem was analyzed in a 3-month period from October 2023 to December 2023. It has been found that the biggest problem is in the Wiper Bending part process type 2. The main cause is that the radius of the wiper is not in accordance with the die roll because the base of the wiper is broken and the tip of the wiper is cracked, resulting in NG results of the product that cannot be repaired.

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Failure Mode and Effect Analysis (FMEA) is a method used to identify and use potential failures or problems in a system, process, design, or service. FMEA is an engineering technique designed to improve the reliability and safety of a process (Richma, et al., 2015). According to PT Widya Mesindo Raya, the Pipe Bender Machine is one type of machine that is widely used in the industrial world. This machine has a way of bending a workpiece that is usually made of metal. There are two types of commonly used bending machines, namely pipe bending machines (pipe bending machines) and plate bending machines. In pipe bending machines, the pipe bending process is carried out by manual or automatic pipe bending machines such as hydraulic pipe benders.

The Pipe bender machine, or often referred to as a bending machine, has the main function of applying pressure to an object to produce plastic deformation, which is a permanent change in the shape of the object. This process is often referred to as the bending process, which usually refers to the activity of bending iron materials. Types of iron that are generally bent include iron plates and cylindrical pipes (PT Persada Dinamika Jaya, 2021). Quality is a description of the characteristics of a product and its attributes are able to show its ability to meet needs, therefore it is necessary to have a match between the desires of the business world and consumers in creating a product so that it can give a distinct impression to consumers (Wisnubroto & Rukmana, 2015). Quality control is the process control activity for product quality characteristics, comparing them with specifications or requirements, and taking appropriate health measures if there is a difference in the original appearance from the standard appearance. The purpose of quality control is to control the quality of products or services that can bring satisfaction to consumers (Elma, 2017). According to Bastian in his research (Rahayu et al., 2020), Defect is a product produced in the manufacturing process, if the product produced does not meet the specified quality standards. The company strives to reduce production defects or defects with various customer satisfaction efforts. One of the efforts that can be made to reduce defects is to carry out quality control and quality improvement during the manufacturing process. One of the methods that companies often use to improve quality is the Quality Control Circle or often called QCC. Gasperz (2011) in his journal (Khamaludin a Respati, 2019) states that QCC is a group of workers or employees who aim to improve the quality and efficiency of Production with voluntary ownership, regular meetings, continuous improvement. The group of employees is formed a team led by a leader and monitored by existing facilitators determined by the company.

Method

Integration of Failure Mode and Effects Analysis (FMEA) into the research that has been conducted. The FMEA (Failure Mode and Effect Analysis) method is a systematic approach to identify and analyze potential failures, products or processes. An overview of the idea of the FMEA method is as follows:

- Identify Failure Modes.
- Potential Causes of Failure
- Effects of Failure
- Risk Assessment
- Risk Mitigation Strategies
- Evaluation of Mitigation Effectiveness

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Result and Discussion

Identification of Failure Modes

Based on the results of the previous analysis, the main failure modes identified are:

1. cracks in the wipers.

Figure 1. Cracks in the wipers

2. Mandrel Damage
3. The mismatch of the radius of the wiper with the die roll, causes the part to wrinkle and corrugation.

Figure 2. The mismatch of the radius of the wiper with the die roll, causes the part to wrinkle and corrugation.

Potential Causes of Failure

The FMEA analysis attributes each failure mode to the following potential causes:

- The wiper material is too hard (HRB 83.1).
- There is no standard wiper radius specification.
- Unavailability of spare component stock.
- Inconsistency of the engine setup process.

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Effects of Failure

Each failure has a significant impact on production results:

1. Lost Time.

Table 1 Frequency of Problem Line Pipe Bender CNK 3B

It	Part Name	Era			Total	AVG.
		OCT 23'	NOV 23'	DEC 23'		
1.	Pipe Haja	2	3	2	7	2.3
2.	Pipe D Inner	5	6	4	15	5.0
3.	Pipe 2 MD	1	2	1	4	1.3
4.	Pipe Lower	1	0	1	2	0.7
5.	Pipe Rear	6	5	7	18	6.0
6.	Pipe Ewo 031	2	1	3	6	2.0

Table 2 Frequency of Problem Pipe Rear Siha

No.	Part Name	Era			Total	AVG.
		OCT 23'	NOV 23'	DEC 23'		
1.	Wiper Bending 1	2	3	2	7	2.3
2.	Wiper Appeal 2	5	3	4	12	4.0
3.	Mandrell	1	2	1	4	1.3
4.	Engine Error	1	0	1	2	0.7

2. Increase in product defect rate (NG parts).
3. Decreased process efficiency and productivity.

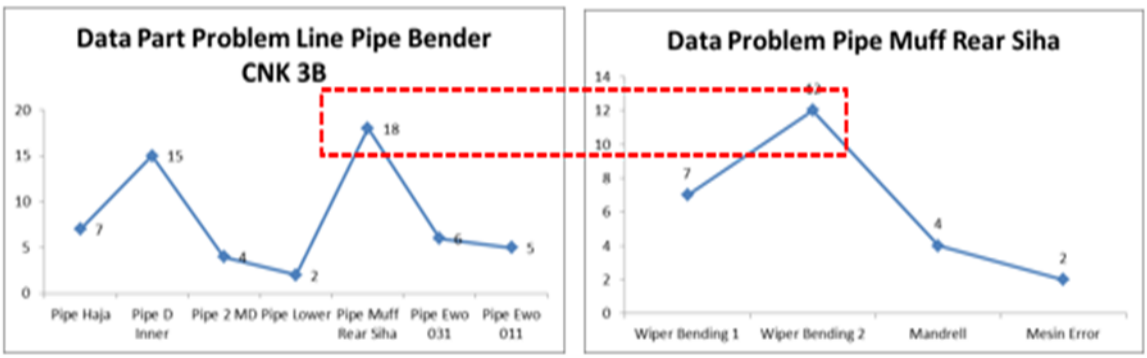

Figure 3 Failure Effect Diagram

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Risk Assessment

Using the FMEA approach, the RPN (Risk Priority Number) value is calculated based on:

1. Severity: The high impact of the failure on product quality (high scale).
2. Occurrence: The high frequency of repeated troubles in the production process.
3. Detection: Limited early detection of the cause of failure.

Risk Mitigation Strategies

The remediation solutions implemented reflect mitigation actions that are in accordance with the results of the FMEA analysis:

1. Reduced Material Risk: changed the hardness specification of the wipper material from HRB 83.1 to HRB 37.1 to improve the durability of the component

Figure 4 : Before and After Changing the Specification of Wipper Material Hardness

2. Adjusting Component Design: Fixed the radius of the wiper from R.100 to R.120 to ensure compatibility with die roll.
3. Improve Process Control: Format the wipper stock data to ensure component availability.
4. Standardization and Training: Provides operators with new guidance on engine setup and training to improve technical understanding.

Evaluation of Mitigation Effectiveness

The results of the fix implementation show that the RPN value for each failure mode is drastically reduced:

1. The frequency of failures dropped by 50%, from 17 to 8 cases per year.
2. Production downtime and product defect rates decreased significantly.
3. The overall process efficiency is improved.

The integration of FMEA in this study ensures a structured risk analysis, helps the team identify remediation priorities, and improves the sustainability of the implemented solution. This research was conducted to overcome the problem of repeated problems in the "Pipe Siha"

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bending process in the PT XYZ Machining Line, which is one of the main causes of the decrease in production efficiency. Based on the initial analysis, it was found that damage to the wipper component was the most dominant problem. The damage includes cracks, fragments, and waves in the base, which has an impact on product results in the form of wrinkled and corrugated parts.

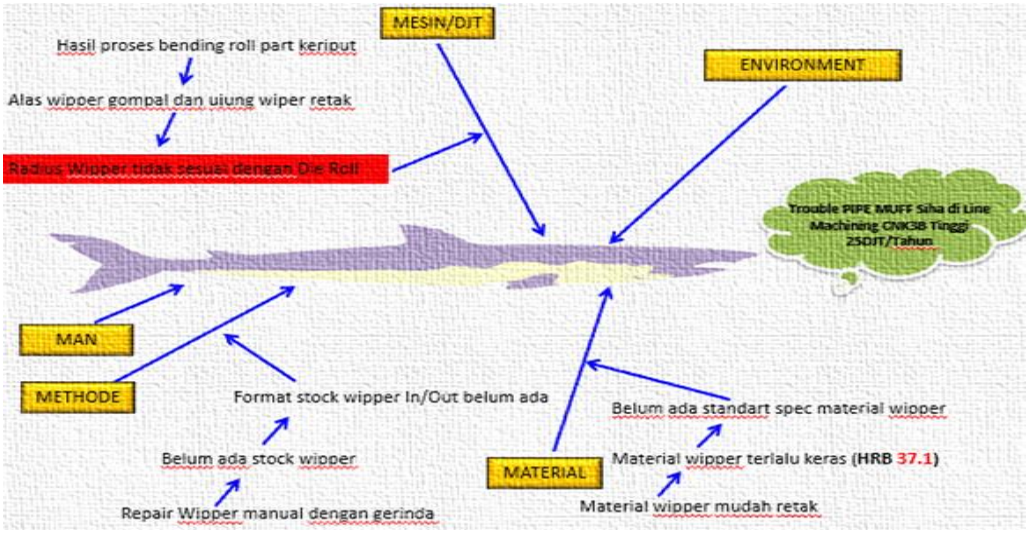

Figure 5 : Fishbone Diagram

In-depth analysis using a fishbone diagram and direct observation (genba) showed several main causes, namely:

1. Material: Wipper material that is too hard (HRB 83.1) so it cracks easily.
2. Engine/DJT: No spare wipper stock available and no component stock control format.
3. Method: There is no standard specification of the radius of the wipper that corresponds to the die roll.
4. Environment and People: Lack of technical understanding regarding repair standard procedures.

To overcome these problems, several improvement steps are carried out as follows:

1. Technical Specification Change: The wiper radius was changed from R.100 to R.120 to reduce the risk of wrinkled parts. The hardness of the material was also lowered from HRB 83.1 to HRB 37.1 to improve the flexibility and resistance of the material.
2. Creation of Stock Control System: Created wipper stock data format (in/out) to ensure the availability of backup components.
3. Production Process Standardization: New guidelines for machine setup have been created to make the process more consistent and the risk of errors can be minimized.

Conclusion

The results of the evaluation showed that the improvements made succeeded in achieving the planned target. The frequency of damage has been successfully reduced by 50%, from 17 cases to 8 cases per year. In addition, production lost time is significantly reduced,

thereby increasing the efficiency and stability of the production process. Standardization is also carried out to ensure the sustainability of repair results, including standardization of material specifications, engine setup guidelines, and component stock control. This study shows that a systematic approach based on QCC (Quality Control Circle) is very effective in identifying and resolving production problems in a sustainable manner, which ultimately has a positive impact on the company's overall performance. This research can be a reference in the application of continuous improvement methods to increase efficiency in the manufacturing sector.

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