Analysis of Yarn Quality Control Using FMEA and FTA Methods to Minimize the Occurrence of Non-Conforming Product (NCP) PT. XYZ

Adam Muchammad Burhanuddin
Undergraduate Program in Industrial Engineering Department, Faculty of Engineering
Universitas Sebelas Maret Surakarta, Jl. Ir. Sutami, 36 A, Surakarta, Indonesia
adammb2001@student.uns.ac.id

Wahyudi Sutopo
University Centre of Excellence for Electrical Energy Storage Technology
Department, Faculty of Engineering
Universitas Sebelas Maret, Surakarta, Jl. Ir. Sutami, 36 A, Surakarta, Indonesia
wahyudisutopo@staff.uns.ac.id

Abstract

PT. XYZ is a textile company (spinning yarn) that produces several semi-finished products in the form of cotton yarn, polyester, viscone rayon, and many more. This company has several problems in its business processes. The problem that arises is the unclear Standard Operating Procedure (SOP) that the company has set which causes errors or disturbances in the production process. Another problem is the presence of a defective final product. For this reason, it can be seen the problems in the system that have been running so that improvements need to be made so that the problems that occur can be overcome by methods that can be used to control production quality, namely by using Failure Mode and Effect Analysis (FMEA), and Fault Tree Analysis (FTA). The conclusion of this study is the calculation using the FMEA method and processing using the FTA method, obtained several suggestions for the root cause of each problem that exists. There factors that cause defects that cause Non-Conforming Product (NCP) are humans, method, material, machine and environment factors. The proposed improvement to reduce product defects is to apply the proposed improvement which has been processed using the FTA method.

Keywords
Yarn Quality Control; Failure Mode and Effect Analysis (FMEA); Fault Tree Analysis (FTA).

1. Introduction
PT. XYZ is a textile company (spinning yarn) that produces several semi-finished products in the form of cotton yarn, polyester, viscone rayon, and many more. Since the inception of PT. XYZ until now, this company has made various kinds of production changes. Starting from the beginning which produces cloth until now, which only focuses on yarn production. PT. XYZ currently also produces not only one type of yarn, but also a variety of different yarns in each unit. Changes in the types of production are carried out by the company in order to remain competitive in the textile market in the national and international markets. Therefore, until now this company can still exist in the textile market and also continue to run its production smoothly.

In its production activities, PT. XYZ uses sophisticated production machines with the help of competent human resources. In the production process, each work station uses modern and sophisticated machines. Starting from the raw material process to the packaging process, everything is fully machined in the process. By using machines in each production process, the production target becomes easier to achieve because the output produced has the same specifications. In addition, the use of modern machines can also save the company's expenses, because only a few workers are needed. In the production process flow, quality control is also carried out in each part of the production process, from raw materials to the packing process. Supervision and quality control in each process is carried out to maintain the quality of the final product produced. In addition, improving product quality will also greatly affect product sales, the better the product quality, the better sales will also be. Meanwhile, when product quality deteriorates, customers will start to leave the product, and in the end it will have an impact on sales decline. Based on the results of observations and interviews, it is known that there are several problems in the business process. The problem that arises is the unclear Standard Operating Procedure (SOP) that the company has set which causes errors or disturbances in the production process. Another problem is the presence of defective final products or defects that do not pass quality control such as cross thread defects, wrinkle rolls, non-standard weights, and others.

For this reason, it can be seen the problems in the system that have been running so that improvements need to be made so that the problems that occur can be overcome by methods that can be used to control production quality, namely by using Failure Mode and Effect Analysis (FMEA), and Fault Tree Analysis (FTA). Previous research by fernandi (2022) which discusses the risk of failure of the polyester fabric process using FMEA method at PT Karawang and aims to analyze the failure modes that cause product defects using the FMEA method. FMEA is used to determine the cause of failure or defect in a product, this method serves to determine the value of the Risk Priority Number (RPN), a value that exceeds the critical number will be further identified to determine the root cause of the problem using the Fault Tree Analysis (FTA) method. From the root cause of each problem, a proposed improvement can be determined, so that it can assist the company in overcoming the existing problems. Therefore, this study was made to find out the root cause of each problem related to the occurrence of product defects and determine proposed improvements that can be applied to the production process so that companies can minimize defects that occur so that company productivity can increase. The purpose of this study is to determine the occurrence of the product that occurs, the factors that cause it, and provide solutions to overcome the product that occurs.

2. Literature Review

A Pareto chart is a bar graph that shows problems in order of the number of occurrences, starting from the most problems to the least. Kusumah et al. (2019) explains that the problem looks dominant in the Pareto diagram, so it can be seen that the solution to the problem of the Pareto diagram function is to identify or select the main problem to improve the quality from the largest to the smallest. Pawellangi et al. (2020) shows that the function of the Pareto diagram is to identify or select the main problem to improve the quality from the largest to the smallest. Caldeira et al. (2018) states that the Pareto Principle is based on the idea that 80% of outcomes are based only on 20% of factors, justifying prioritization. faced and compared to the whole. Pareto analysis is guided by the 80-20 rule which states that about 80% of problems are caused by only 20% of factors.

Cause-and-effect diagrams are also known as fishbone diagrams. Coccia (2018) explains that fishbone diagrams (shaped similar to a fish skeleton) are a common tool used for cause and effect analysis to find complex causal interactions for specific problems or events. Al-Kubaisi (2018) explains that fishbone diagrams are one technique that can be used to identify the causes of construction failures, which are a recurring phenomenon in several projects. Basavaraj et al. (2019) stated that fishbone diagrams can describe all the root causes of defects and then analyzed through Pareto diagrams. This diagram is used to determine what factors are the cause of a problem. Doshi et al. (2012) mentions the root causes and sub-clauses, which imperfection problems can lead to into categories such as Humans, Machines, Materials and, Methods and Environment.

Failure Mode and Effects Analysis (FMEA) is a failure analysis or potential failure that is applied in product development, systems engineering and operational management. Housmand et al. (2021) stated that Failure Mode and Effect Analysis (FMEA) is an effective risk analysis and failure avoidance approach in design, process, service, and system. Wang et al. (2020) explains that Failure mode and effect analysis (FMEA), aims to identify and determine the potential failure modes in a system, is widely used in various fields to improve and improve the system because it is a strong and useful risk. and assessment of instrument reliability. FMEA was started in the 1940s by the US military where this approach contains a step by step approach to finding all possible failures in a design, manufacturing or assembly process, or product or service. The following are common analytical tools, divided into three. Process, FMEA used for manufacturing and assembly processes. Design, FMEA which is used to process the product before the production process. Service, FMEA which is used for the service process from the service industry process before it is launched to the customer. The process in this method is to determine the value of Severity, Occurrence, and Detection. After that, determine the value of the Risk Priority Number (RPN). Deng et al. (2019) shows the risk priority score (RPN) is the product of three indicators of severity (S), probability of occurrence (O), and detection (D), which are important measures for determining risk priority.

The next step is to create a fault tree, Bhatt et al. (2012) explain the causes of defects in the form of a tree diagram using standard logical symbols. Fault Tree Analysis (FTA) is a one-way diagram and relates the information developed in analyzing failure modes and consequences. Asobatin (2017) Fault Tree Analysis (FTA) method to identify the root causes of product defects based on the production process through a tree root diagram. In this method, the proposed improvement of each root problem can be determined for further improvement.

3. Methods

The research process begins with conducting a field study at PT. XYZ. Next, do a literature study in the form of the methods used in the research and also the production process. Then proceed with identifying problems with the company. The next process is to determine the goals, benefits, and limitations of the problem. The limitation of the problem is in the form of research that is only carried out in one of the production processes and the data used is data in 2021. After that, data was collected using direct observation method at PT. XYZ, interviews, and documentation data. Then proceed with data processing and analysis using Pareto diagrams, fishbone diagrams, FMEA and FTA methods. The final step is to draw conclusions and make suggestions. Finally, after all the processes are complete, conclusions can be drawn and suggestions can be made (Figure 1).

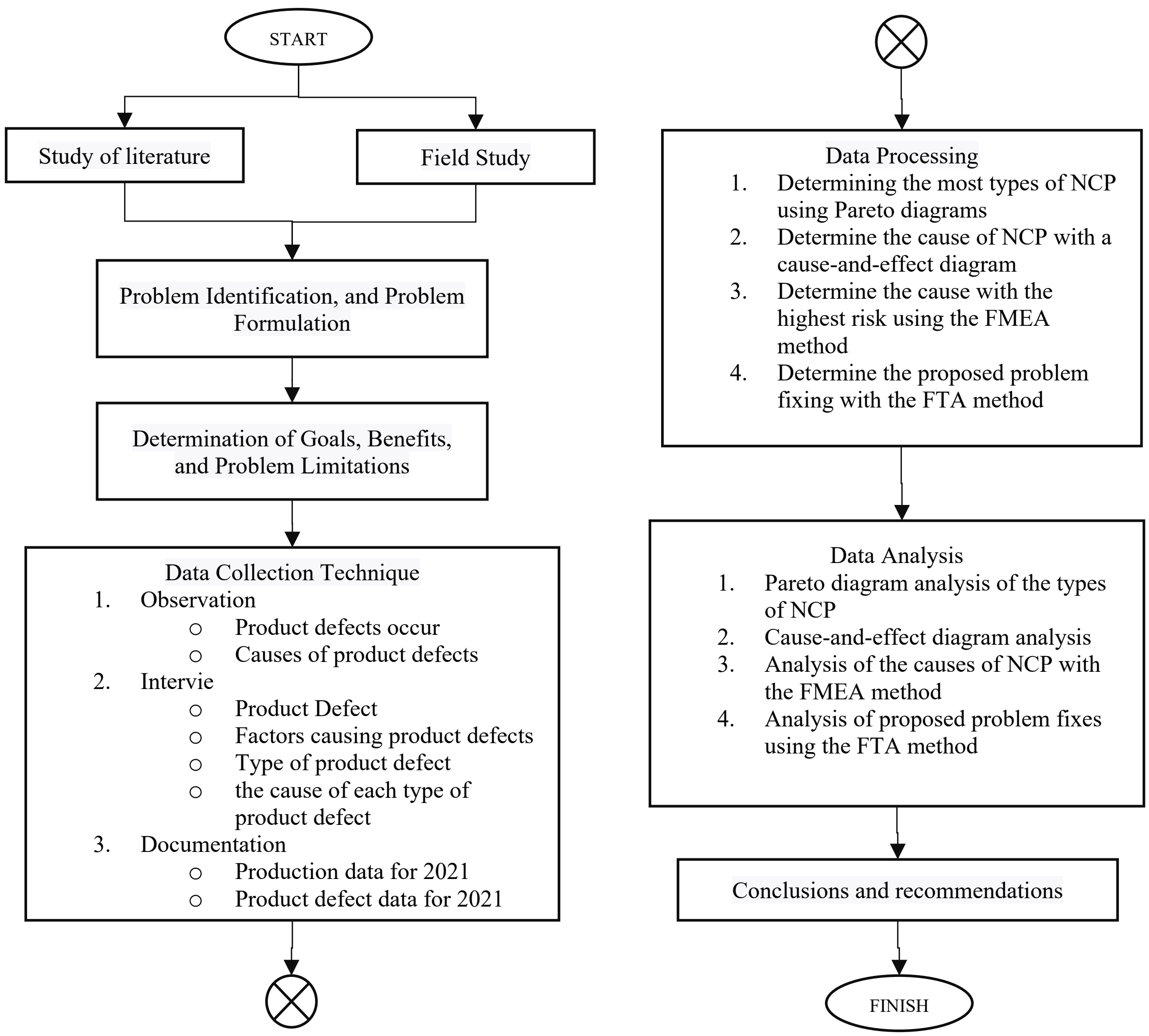

Figure 1. Methods Flowchart

4. Results and Discussion

This section will explain the results and analysis of this study. This chapter describes some of the data and processing of the data obtained.

4.1 Pareto Chart

Based on the non-conforming product (NCP) data recapitulation table, it can be seen that the percentage of the most common types of defects occurs by using a Pareto diagram. The following is a Pareto diagram of the non-conforming product (NCP) winding unit spinning unit I PT. XYZ in 2021 (Figure 2).

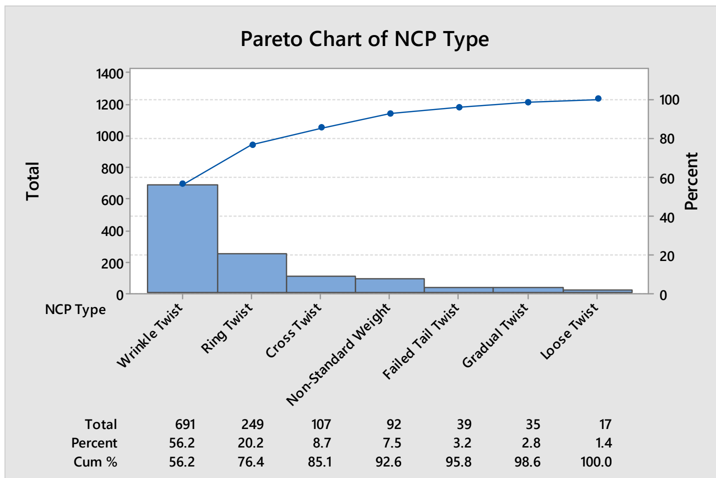

Figure 2. Pareto Chart Type of Non-Conforming Product (NCP)

Based on the non-conforming product (NCP) data recapitulation Table 2, it can be seen that the percentage of the most common types of defects occurs by using a Pareto diagram. The following is a Pareto diagram of the non-conforming product (NCP) winding unit spinning unit I PT. XYZ in 2021.

Tabel 2. Recapitulation of Types of Non-Conforming Product (NCP) 2021

NCP Type	Total	Percent	Percent Cumulative
Wrinkle Twist	691	56,2%	56,2%
Ring Twist	249	20,2%	76,4%
Cross Twist	107	8,7%	85,1%
Non-Standard Weight	92	7,5%	92,6%
Failed Tail Twist	39	3,2%	95,8%
Gradual Twist	35	2,8%	98,6%
Loose Twist	17	1,4%	100,0%

Pareto diagrams can be used to find 20% defects which are 80% defects in the entire production process. Based on this, from the table of percentage types of NCP above, it is known that the non-conforming product (NCP) of which is included in the cumulative 80% is in the type of NCP wrinkle twist, ring twist, and cross twist.

4.2 Fishbone Diagram Design Causes of Defect

The design of this diagram is based on direct observations in the field and also interviews with employees who have responsibility for the winding process. The following is a fishbone diagram of NCP (Figure 3).

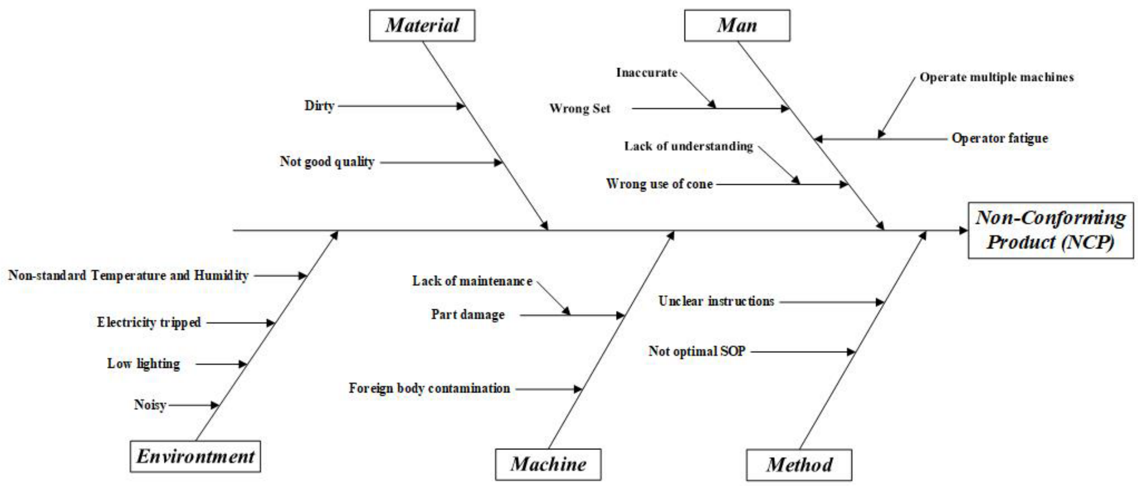

Figure 3. Fishbone Diagram Non-Conforming Product (NCP)

4.3 Calculation of Risk Analysis with the Failure Mode and Effect Analysis (FMEA) Method

In this method, it is known the potential effect of failure and potential cause of failure. The following is a table of potential failure modes, potential effects of failure and potential causes of failure (Table 3).

Tabel 3. Potential Failure Mode, Potential Effect of Failure, dan Potential Cause of Failure

Potential Failure Mode	Potential Effect of Failure	Potential Cause of Failure
Operator level of accuracy	Wrinkle Twist	Wrong tension setting on the engine
Engine performance level	Ring Twist	Lack of resulting twist
Machine inconsistency	Cross Twist	Untidy twist

The next stage is to calculate the value of the Risk Priority Number (RPN). In the Failure Mode and Effect Analysis (FMEA) method, the RPN value is used to determine which failure mode should be prioritized for handling. The RPN value is obtained from the product of the Severity (S), Occurance (O) and Detection (D) values (Table 4).

Tabel 4. Severity, Occurrence, and Detection Values

No	Potential Failure Mode	Indicator Value			
		Severity (S)	Occurrence (O)	Detection (D)	RPN
1	Operator level of accuracy	8	7	6	336
2	Engine performance level	6	6	5	180
3	Machine inconsistency	4	3	2	24

Based on the results of the calculation of the RPN value above, the value of the calculation can be ordered starting from the largest RPN value to the smallest RPN value. This RPN shows the priority level of a failure mode obtained from the analysis results in the analyzed process. This is done to facilitate the implementation of priority corrective actions in the potential failure mode that has the greatest risk value (Table 5).

Tabel 5. Risk Priority Number (RPN) Value

No	Potential Failure Mode	RPN
1	Operator level of accuracy	336
2	Engine performance level	180
3	Machine inconsistency	24
Total		**540**

The next process is to make a Pareto diagram to determine the percentage and determine the potential failure mode which is included in the 80% cumulative percentage area. The following is a Pareto diagram of the RPN value for each potential failure mode (Figure 4).

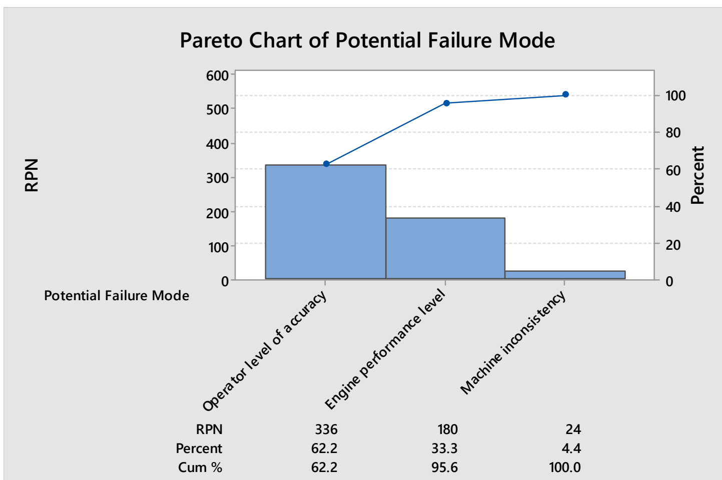

Figure 4. Pareto Chart RPN

The following (Table 6) is the percentage recapitulation data obtained from the Pareto chart above (Figure 4).

Tabel 6. Risk Priority Number (RPN) Recapitulation

Potential Failure Mode	RPN	RPN Percentage	RPN Cumulative Percentage
Operator level of accuracy	336	62,2	62,2%
Engine performance level	180	33,3	95,6%
Machine inconsistency	24	4,4	4,4%

Before determining the potential failure mode which will be further processed, it is necessary to determine the critical value first. The critical value is used to determine the risks that fall into the high risk category. The risk that is included in the high category is the risk with the RPN value greater than or equal to the critical value. The formula for the critical value is as follows:

$$\boldsymbol{Critical\ Value = \frac{Total\ RPN}{Number\ of\ Potential\ Failure\ Modes}}$$

After knowing the formula for determining the critical value, then the table above can also know the critical value. The following is the calculation of the critical value in the table above:

$$Critical\ Value = \frac{540}{3}$$
$$= 180$$

Based on the calculation of the RPN value above, it is known that the potential failure mode is included in the cumulative 80% and is more than the same as the critical value limit, operator level of accuracy with an RPN value of 336 and the level of engine performance level with an RPN value of 180.

4.4 Proposed Improvement with Fault Tree Analysis (FTA) Method

Fault Tree Analysis (FTA) method is processing that is carried out using a tree diagram that shows the root of a problem that exists in terms of the causal relationship of each of these problems. Analysis of this method can be used to find the main root cause of an existing problem, so that later it can be repaired in order to minimize product defects in subsequent productions. The following is a Fault Tree Analysis (FTA) diagram of the factors that have a critical final RPN value, namely the level of operator accuracy and the level of machine performance.

The following is a Fault Tree Analysis (FTA) diagram on the operator's level of accuracy factor (Figure 5).

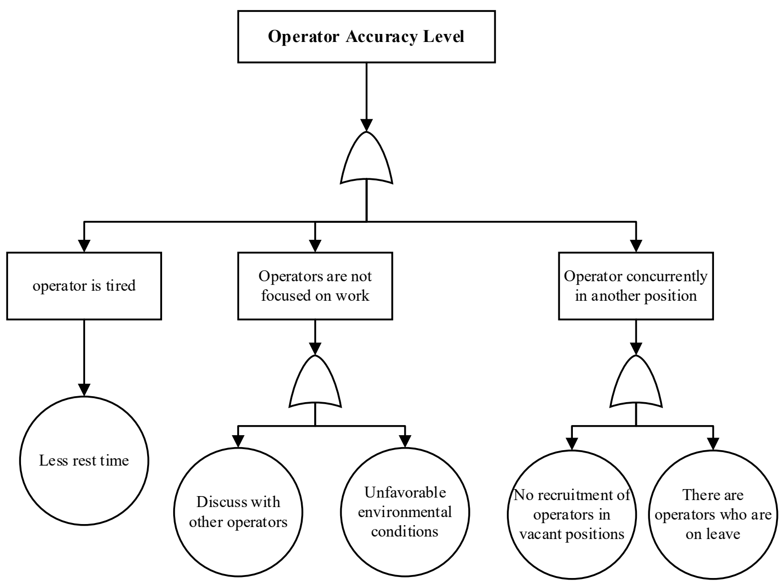

Figure 5. Fault Tree Analysis (FTA) Diagram on Operator Level of Accuracy

The following is a Fault Tree Analysis (FTA) diagram on the engine performance level factor (Figure 6).

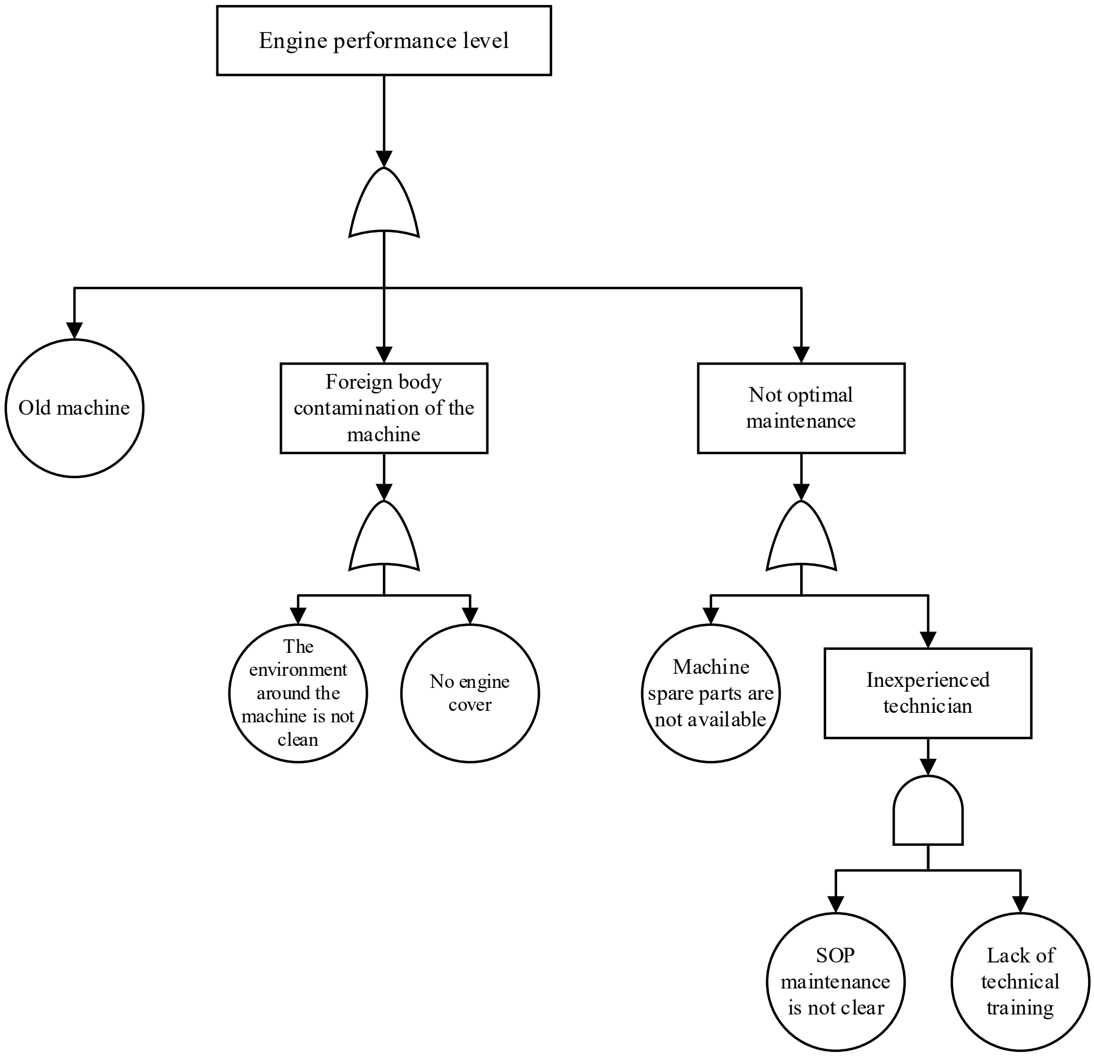

Figure 6. Fault Tree Analysis (FTA) Diagram on Engine Performance Level

After knowing what the root causes of the two factors in the Fault Tree Analysis (FTA) diagram above are, the next step is to make suggestions for improvements to the company in order to minimize product defects that occur. Table 7 shows the proposed improvements for each root cause of the problem.

Based on the list of proposed improvements for each of the root causes of the problems above, it is hoped that the company can review the production process in the winding process and can also implement the proposed improvements that have been designed. With this list of proposed improvements, it is hoped that PT. XYZ can apply it so that the resulting product defects can be minimized so that the amount of production and efficiency can be more optimal (Table 7).

Tabel 7. List of Proposed Improvements

No	Potential Failure Mode	Root Cause	Improvement Proposal
1	Operator level of accuracy	Less rest time	Giving a little rest time for each production batch
		Chat with other operators	Confirming related SOPs and providing more supervision
		Unfavorable environmental conditions	Make improvements to the production environment according to the standards set
		No recruitment operator in vacant positions	Conducting recruitment of operators in accordance with the required number to avoid operators who work concurrently
		There are operators who are on leave	Adjusting the position of the operator who is on leave with other operators
2	Engine performance level	Old machine	The machine is replaced with a new one
			Perform regular machine maintenance
		The environment around the machine is not clean	Cleaning the environment around the machine every shift
		No engine cover	Provide cover on machine parts that are at high risk of contamination with foreign objects
		Machine spare parts are not available	Provide spare parts, especially for parts that are often damaged
		SOP maintenance is not clear	Make improvements to related SOPs so that later misunderstandings don't arise
		Lack of technical training	Make a training schedule with discussions about routine maintenance

5. Conclusion

The conclusions obtained from data processing and analysis of practical work reports at PT. XYZ is based on the Pareto diagram the most common product defects during 2021 are corrugation rolls, ring roll coils, and cross rolls. There are 5 factors that cause defects that cause Non-Conforming Product (NCP), namely man, method, material, machine and environment factors. The proposed improvement to reduce product defects is to apply the proposed improvement which has been processed using the FTA method.

Based on research that has been done at PT. XYZ and the conclusions made, there are several suggestions that can be considered by the company in its efforts to improve production quality control. Suggestions that can be given are that supervision is applied when implementing quality control of raw materials, production processes and when finished products should be further improved so that they can be controlled properly. The company should immediately take action against the factors that lead to the occurrence of Non-Conforming Product (NCP). Further research is needed to examine problems related to the production process at the company.

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Biographies

Adam Muchammad Burhanuddin is currently an undergraduate student in Industrial Engineering at the Faculty of Engineering, Universitas Sebelas Maret.

Wahyudi Sutopo is a professor of industrial engineering and coordinator of the industrial engineering and techno-economics research group (RG-RITE) Faculty of Engineering, Universitas Sebelas Maret (UNS), Indonesia. He earned his Ph.D. in Industrial Engineering & Management from the Bandung Institute of Technology in 2011. He is also a researcher for the university center of excellence for electrical energy storage technology (UCE-EEST). He has undertaken projects with the Indonesian education endowment fund (LPDP), the continuing higher education research alliance (SHERA), the MIT-Indonesia research alliance (MIRA), PT Pertamina (Persero), PT Toyota Motor Manufacturing Indonesia, and various other companies. His research interests include logistics & supply chain management, economics engineering, cost analysis & estimation, and technology commercialization. He is a board member for industrial engineering - the Indonesian Engineers Institute (BKTI-PII), the Indonesian Supply Chain & Logistics Institute (ISLI), the Society of Industrial Engineering, and Operations Management (IEOM), and the Institute of Industrial & System Engineers (IISE).