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Conference Paper

Welding Quality Control Using Statistical Quality Control (SQC) Methods and Failure Mode Effect Analysis (FMEA) at PT. XYZ

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ABSTRACT

PT. XYZ is the largest shipbuilding company in Indonesia. The company's products are shipbuilding and ship design based on consumer demand. In the production process of the BRS W-303 ship, defects were still found during welding, such as incomplete penetration and slag inclusion. The purpose of this study was to determine the percentage of the most dominant defects and the factors causing defects and to provide suggestions for improving the quality of welding. The methods used are Statistical Quality Control (SQC) and Failure Mode Effect Analysis (FMEA). SQC tools are check sheets, stratification, scatter diagrams, attribute control charts, and cause and effect diagrams. Then continue the FMEA analysis based on the cause-and-effect diagram for proposed improvements. Based on the results of Statistical Quality Control (SQC) research, it is known that the most dominant ship welding defects are incomplete penetration (32.81%) and slag inclusion (23.26%). Based on the results of research on Failure Mode Effect Analysis (FMEA) it is known that the root cause of the highest problem with RPN 288 is the determination of the root gap is too small or narrow. Recommendations for improvement that can be proposed are to ensure that the welder must read and understand the WPS used to weld correctly.

Keywords: Failure mode effect analysis, statistical quality control, welding quality.

Introduction

Companies in the industrial world, both manufacturing and service industries are required to face market competition in order to be able to compete and survive. One of the important factors for the sustainable development of the company is the quality of the products it produces (Shania et al., 2022). High-quality products are products that meet consumer needs and have no defects in the final product. In order for a company to develop or survive in the industrial world, it must be able to provide high-quality goods or services according to the needs and desires of consumers and maximize the use of resources to achieve these goals.

Product quality control is a very important factor for the industry (Qothrunnada et al., 2022), because good quality control and continuous application can quickly detect abnormalities so that corrective and anticipatory actions can be taken immediately. This is also to ensure the quality of the company's production or service (Latifah et al., 2022). To maintain the quality of the products produced to meet market demand, quality control must be carried out in accordance with the process activities carried out. Thus, improving quality will further reduce the level of defects in a product.

PT. XYZ is the largest shipbuilding company in Indonesia. In the ship production process, PT. XYZ tries to provide the best for consumers in terms of the quality of the BRS W-303 shipbuilding, where during the welding process there are still some welding defects, namely Slag Inclusion and

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Incomplete Penetration. The welding parts observed in the production of the BRS W-303 ship are ME Seat (Engine Bed), Stern Tube, House Pipe Block FP, and Fore Bullbouse Bow (FBB). From all welding parts observed, it is known that the number of defects in the welding of the BRS W-303 ship with a total defect of 8.7%.

Based on the explanation of the problems that have been explained, this study aims to determine the percentage of the most dominant defects and the factors causing defects and provide suggestions for improving welding quality. Statistical Quality Control is a system that maintains uniform product quality standards at the lowest cost to achieve an effective level (Andespa, 2020). Therefore, by the problems above, the researcher applies the Statistical Quality Control (SQC) method to determine the causes of product defects and Failure Mode Effect Analysis (FMEA) analysis to provide suggestions for corrective actions against welding quality control at PT. XYZ.

Literature Review

Statistical quality control

Statistical Quality Control is a system by maintaining quality standards in the production process with the minimum possible cost, collects data, and analyzing data using statistical methods (Andespa, 2020). Statistical Quality Control can prevent deviations in the process (Vikri, 2018). So, Statistical Quality Control is a system to eliminate existing deviations or causes to conform to the production standards set by the company (Arianti et al., 2020). Seven tools are seven main tools for solving problems encountered in the production process, especially those related to quality. The seven tools are check sheets, stratification, histograms, Pareto diagrams, scatter diagrams, control charts (control maps), and also fishbone diagrams (Susetyo, 2013).

Failure Mode Effect Analysis

FMEA (Failure Mode and Effect Analysis) is an improvement strategy used in the identification, risk assessment, and prioritization of risks that must be addressed. The main purpose of using FMEA is to identify potential failure modes within the system unit (Saifuddin et al., 2022; Erwindasari et al., 2020), evaluate their subsequent effects on system performance, and consequently recommend strategies to eliminate or reduce their occurrence or severity and improve detection of specific failure modes (Lo et al., 2018). In general, there are two types of FMEA, namely process FMEA and design FMEA. In the FMEA process, the observation focuses on the design production process, while the FMEA design focuses on the product design (Suwandi et al., 2020).

Following are the steps in analyzing the FMEA method:

1. Identify the failure mode
2. Determine the severity value
3. Determine the value of the failure rate (occurance) that often appears
4. Determine the detection value of the occurrence of failure
5. Calculating the results of the RPN calculation
   RPN = Severity (S) x Occurance (O) x Detection (D)
6. Sort the RPN values from largest to smallest to take corrective action according to the largest RPN value

Material and Methods

The description of the problem-solving steps is to conduct a survey on the existing problems to determine the problem formulation and research objectives, then identify the dependent variable (welding quality) and the independent variable (type of welding defect). Then collect research data including primary data from interviews with the QC division and secondary data in the form of Ultrasonic Test (UT) data for welding the BRS W-303 ship. Next, do the data processing using Statistical Quality Control (SQC) method with seven tools approach, namely check sheet, stratification, histogram, Pareto diagram, scatter diagram, p attribute control chart, and cause and effect diagram, then brainstorm to provide suggestions for improvement with Failure Mode analysis. Effect Analysis (FMEA) is based on the calculation of the RPN value from the multiplication of Severity (S), Occurance, and Detection (D). In this research, used Statistical Quality Control (SQC) and Failure Mode and Effect Analysis (FMEA) analysis. The following steps to solve this problem are as follows figure 1:

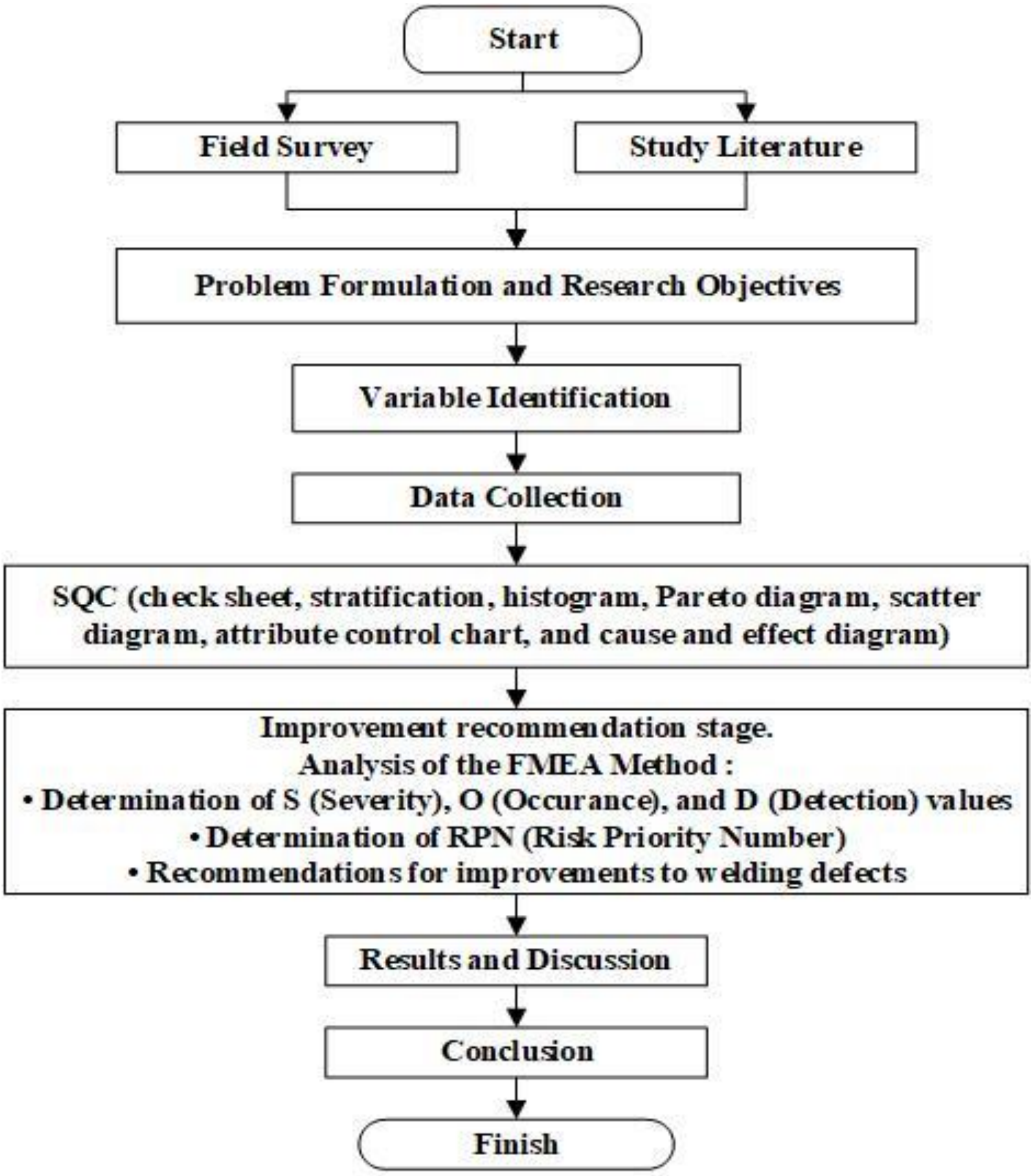

Figure 1. Research methods

Results and Discussion

The data used in this study is data during the production process of the BRS W-303 ship, namely welding production data with a total of 51647 mm and welding defect data with 2 types of defects namely Slag Inclusion and Incomplete Penetration. Then the data is processed using Statistical Quality Control and Failure Mode Effect Analysis (FMEA) methods.

Statistical Quality Control (SQC)

Check Sheet

Check sheet is a tool used to record the results of data collection and present the data in a communicative form. In Table 1, it can be seen the results of data collection according to the check sheet.

Table 1. Checksheet

No	Item	Type of Defect	
		Slag Inclusion	Incomplete Penetration
1	Me Seat (Engine Bed) Engine Girder 1 (S)	eeeeeeea	Eeeee Eeeeea
2	Me Seat (Engine Bed) Engine Girder 1 (P)	eeeeeec	Eeeee Eeeed
3	Me Seat (Engine Bed) Engine Girder 2 (S)	Eed	Eeeeb
4	Me Seat (Engine Bed) Engine Girder 2 (P)	Eed	Eeeea
5	Fore Bullbouse Bow (FBB)	Eee	Eeeeb
6	House Pipe Block FP (P)	Eeeee Eea	Eeeee Eeee
7	Stern Tube (P)	Eeeee E	Eeeee Eeec
8	Stern Tube (S)	Eeeee eb	Eeeee eeeb

Source: Internal Data of PT. XYZ

Information:

A = 5 mm (1 line represents 5 mm)

Stratification

Stratification is the stage for categorizing data into groups that have the same characteristics. The criteria set are defects in the welding of the BRS W-303 ship with two types of defects, namely Slag Inclusion and Incomplete Penetration. Table 2 shows the results of the stratification according to the check sheet.

Table 2. Stratification

Items	Production (mm)	Type of Defect		Defect (mm)
		Slag Inclusion	Incomplete Penetration	
Me Seat (Engine Bed) Engine Girder 1 (S)	8400	180	255	435
Me Seat (Engine Bed) Engine Girder 1 (P)	8400	165	245	410
Me Seat (Engine Bed) Engine Girder 2 (S)	3697	70	110	180
Me Seat (Engine Bed) Engine Girder 2 (P)	3180	70	105	175
Fore Bullbouse Bow (FBB)	3480	75	110	185
House Pipe Block FP (P)	8690	180	225	405
Stern Tube (P)	7900	150	215	365
Stern Tube (S)	7900	160	210	210
Σ	**51647**	**1050**	**1475**	**2800**

Source: Internal Data of PT. XYZ

Scatter diagram

Based on Figure 2, the two types of defects, namely Incomplete Penetration and Slag Inclusion on welding production, the results show that from the two types of defects there is a positive correlation where an increase in the X variable is followed by an increase in the Y variable, so that an increase in welding results in an increase in the number of defects.

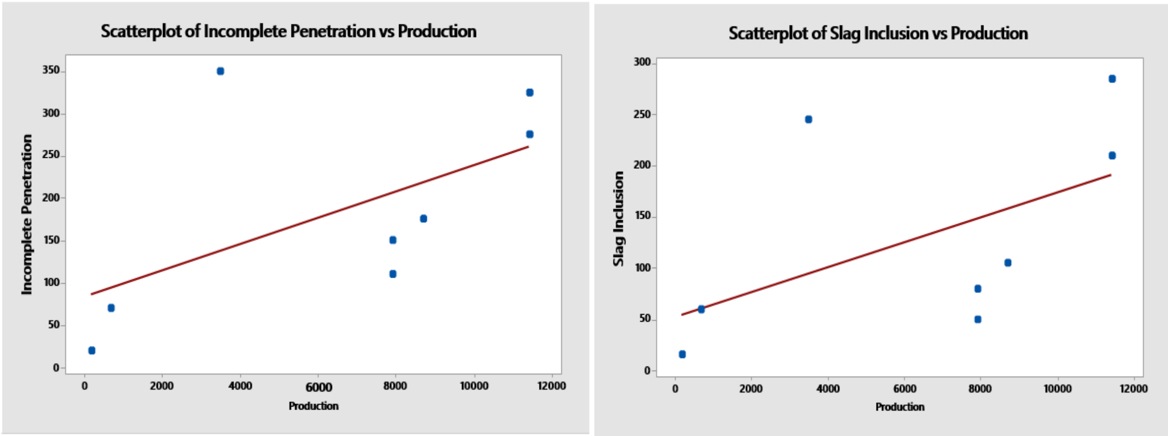

Figure 2. Scatter diagram

Control Chart

Based on Figure 3, the p attribute control chart shows that for two types of defects, namely Incomplete Penetration and Slag Inclusion, the defects that occur are still under control (not out of control).

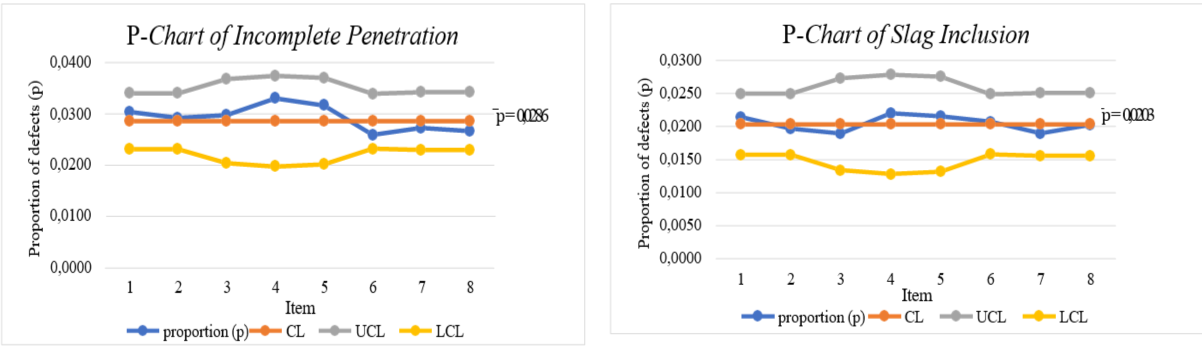

Figure 3. P-Control chart

Cause and effect diagram

Cause-and-effect diagrams are useful for analyzing and knowing the most dominant factors that occur (Saifuddin et al., 2021). With a cause and effect diagram, an analysis of the causes of Incomplete Penetration and Slag Inclusion defects is carried out using a cause and effect diagram (fishbone).

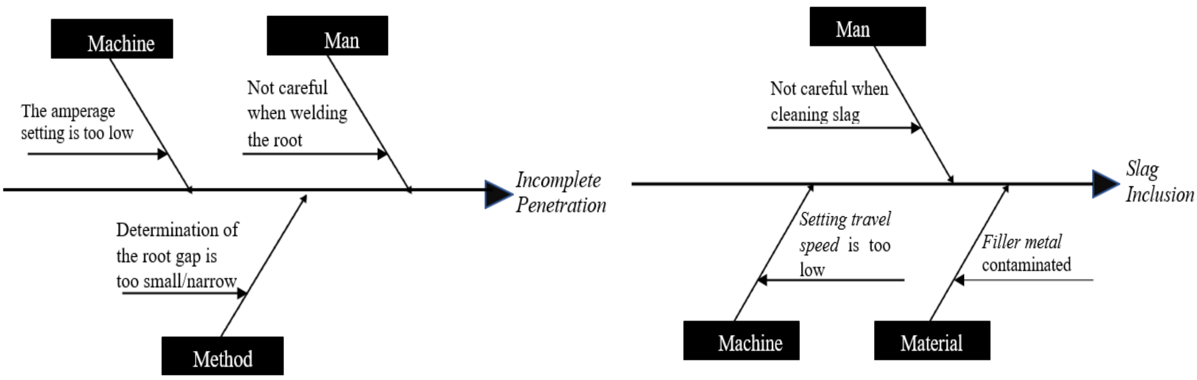

Figure 4. Cause and effect diagram

Failure Mode Effect Analysis (FMEA)

After processing the data with Statistical Quality Control, it is known that the most dominant defects are Incomplete Penetration and Slag Inclusion, according to the causal diagram, the cause of the welding defect of the BRS W-303 ship is known to be carried out with the proposed corrective action using Failure Mode Effect Analysis (FMEA) analysis by determining Risk Priority Number (RPN) values based on Severity (S), Occurance (O), and Detection (D) values are shown in Table 3.

Table 3. Failure Mode Effect Analysis (FMEA)

Potential Failure Mode	*Potential Effect of Failure*	**S**	*Potential cause*	**O**	*Current Control*	**D**	**RPN**
Incomplete Penetration	Will cause a notch that has the potential to crack and then cause SCC (Stress Corrosion Cracking), and reduce weld strength which is fatal to durability and safety	8	The amperage setting is too low	5	Adjust parameters	4	160
			Not careful when welding the root	5	Make a briefing on the welder	3	120
			Determination of the root gap is too small/narrow	6	Adjusting the root gap distance according to the procedure	6	288
Slag Inclusion	Will be the cause of cracks when exposed to load and reduce the strength of the welded joint	6	Not careful when cleaning slag	6	Remind the welder to double check that there are no slags and gaps when cleaning the interlayer	6	216
			Setting travel speed is too low	4	Adjust the travel speed according to the procedure	3	72
			Filler metal contaminated	4	Handle filler metal according to procedure	4	96

Based on the results of the calculation of the RPN (Risk Priority Number) in table 3, it is known that the causes of failure that cause product defects are sorted from high to low value calculations to provide recommendations for improvement of each potential cause. The recommendations based on the order of the RPN can be seen in table 4.

Based on Table 4, it can be seen that the highest cause of disability with the RPN (risk priority number) 288, namely in the incomplete penetration defect with the cause of disability in the determination of the root gap is too small/narrow, and the recommendation of the improvement is to require the welder to be required to read and understand the WPS that will be used correctly.

Table 4. Recommendations for Improvement Based on the Order of RPN

Priority	**Potential Failure Mode**	**Potential cause**	**RPN**	**Recommendation**
1	Incomplete Penetration	Determination of the root gap is too small/narrow	288	Requires the welder to read and understand the WPS that will be used to weld properly
2	Slag Inclusion	Not careful when cleaning slag	216	Supervise the welder more closely when cleaning the slag to avoid repeated buildup of weld residue/slag

To be continued...

3	Incomplete Penetration	The amperage setting is too low	160	Adjusting the amperage parameters according to the WPS used
4	Incomplete penetration	Not careful when welding the root	120	Giving directions to the welder before starting welding and conducting training to be more skilled
5	Slag Inclusion	Filler metal contaminated	96	Use the recommended procedure for storing electrodes
6	Slag Inclusion	Setting travel speed is too low	72	Adjust the welding current and travel speed according to the WPS used

Based on Table 4, it can be seen that the highest cause of disability with the RPN (risk priority number) 288, namely in the incomplete penetration defect with the cause of disability in the determination of the root gap is too small/narrow, and the recommendation of the improvement is to require the welder to be required to read and understand the WPS that will be used correctly.

Conclusion

The conclusion based on the research that has been done is that the dominant defect in welding quality is Incomplete Penetration and then Slag Inclusion. The factors causing the Incomplete Penetration defect are in terms of the machine setting the amperage too low, in terms of humans being less careful when welding the root/root part, and in terms of the working method of determining the root gap is too small/narrow.

Based on the calculation of the RPN FMEA for welding the BRS W-303 ship, it is found that several risks have the highest priority level to make repairs in order to minimize the possibility of errors. Calculation of the highest RPN value is 288 from the Incomplete Penetration (IP) defect type with the cause of determining the root gap being too small/narrow. The recommendation to fix this problem is to require the welder to read and understand the WPS that will be used to weld properly.

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