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Analysis of Quality Control Using the Failure Mode And Effect Analysis (FMEA) Method in the Welding Process in the Feed Drum Project (Case Study at PT. Swadaya Graha)

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ABSTRACT

PT. Swadaya Graha is a steel fabrication company located in Gresik. One of the projects undertaken by PT. Swadaya Graha is a Feed drum Project, the welding process is the most important stage in this project. At the time of product testing or testing there were still many welding points that were defective so that the product did not pass the trial, the trial was carried out by hydrotest where this test was carried out with water as the test medium to determine the strength of a material and find out whether there was a leak or not and as well as a visual check. The types of defects found in the feed drum project are spatter, overlap, porosity, undercut, incomplete fusion, slag, bad String Bead (Weaving Fault), start stop, pin hole. The research uses the FMEA (Failure Mode Effects and Analysis) method which aims to identify and analyze the occurrence of defects. In the results, the highest RPN value is found in the Incomplate Fusion type of defect with a value of 384 so that it becomes a priority in carrying out control and repair **.**
Keywords *: FMEA, Feed drum, Welding Defects, Welding, Quality Control*

Introduction

Quality Control is a process carried out to determine the level of quality of a product. Quality Control is an engineering management activity in which we measure the quality characteristics of a product, compare specifications, and take action when there is a difference between actual and standard performance. (Montgomery, DC, 1990). [1]

Product quality has an indirect impact on business productivity and reduction of production costs, requiring an analysis company to maintain the stability of products manufactured to certain specifications (Matondang & Ulkhaq, 2018). [2] pt. Swadaya Graha is a steel manufacturing company based in Gresik. One of the projects implemented by PT. Swadaya Graha is a Feed Drum Project, the welding process is the most important step of this project. At the time of testing or testing the product there were still many damaged spot welds so that the product failed the test. Testing is carried out using a *Hydrotest*, namely testing carried out using water as a testing medium. material strength and find out whether there is a leak or not. 3] and also a visual inspection. The welding process is a joining process between metals or non-metals in which an integral part is formed by heating the joint material at a certain welding temperature, with no pressure and no additives. [4]

In the welding production process of the *feed drum project,* defects were found , namely:

1. *Spatter*
   Types of welding defects in the form of spots on the surface of the base/material.[5]

Figure 1*Spatter Feed drum Defect*

2. *Overlap*
   Welding defects in the form of welding results that are lower than other welding results.

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Figure 2*Overlap Feed drum* defects

3. *Porosity*
   It has small holes on the surface of the material. [6]

Figure 3*Porosity Feed drum* defects

4. *Undercut*
   Surface or root weld defects, these defects take the form of holes in the base metal or base metal .

Figure 4Undercut *Feed drum defects*

5. *Incompalte Fusion*
   Insufficient welding performance due to joining the metal to be welded to the base metal.

Figure 5*Incomplate* Defect
Fusion Feed drums

6. *Slag*
   Defects in the form of lumps on the welded joint, caused by dirt still in the material.

Figure 6*Slag Feed drum* defects

7. *Bad String Bead (Weaving Fault)*
   The shape of the groove on the welding results is wavy so that the thickness is uneven. [6]

Figure 7*Bad String Bead Feed drum* defects

8. *Start Top*
   Welding results that are not full at the welding site.

Figure 8Defective *Start Stop Feed drum*

9. *Pin Holes*

   Small spots that are in the weld material and have a depth of more than 3 mm.

Figure 9Defective *Pin Hole Feed drum*

Several types of defects can be seen in the *feed drum product* after the checking process uses a *hydrotest* where in this test the product is filled with water to determine the water holding capacity and ensure that the product does not leak when filled with water. There are several welding points that are defective by 40% of the welding process points. Based on the problems above, it is necessary to do research and identify the causes of defects in the welding process in the *feed drum project* . The research uses the *FMEA (Failure Mode Effects and Analysis) method* for the purpose of identifying defects. While the definition of FMEA by Dailey (2004) is a tool for analyzing potential product or process defects, taking into account the risks with this type of failure, identifying and implementing corrective actions to solve serious problems. [7]

The problem that is often faced by the company is the number of welding errors caused by different process operations for researchers to determine the quality of the welding process at PT. swadaya graha, However, this research is a continuation of previous field work practice research because previous research was entitled "Analysis of Quality Control with the *Seventools Method* to Reduce the Number of *Defects in the Feed Drum* Process (Case Study at Pt.Swadaya Graha)" and researchers felt it was less effective , so this time the author uses the FMEA (*Failure Mode Effects and Analysis) method* to identify and analyze the occurrence of errors that occur during the welding of the feed drum project .

Research methods

This research was conducted in the fabrication workshop of Pt. Swadaya Graha. The time for the production process for the feed drum project is in May - June 2022. The research data collection uses primary data obtained from interviews, observation and visual checking, while secondary data is obtained from literature review, technical reports on machines owned by the company. The data used is data on the type of weld defects collected when checking the product using a *hydrotest* as well as the results of interviews with quality control inspections from the company.

FMEA (Failure Mode Effects and Analysis)

FMEA is a structured method for detecting and preventing a number of errors. FMEA is used to identify the root causes of quality problems [8]. Failed methods are anything that involves defects/errors in the design, conditions outside the stated specifications, product modifications that result in product failure. [9] This method can also be used to detect, identify, reduce or eliminate known and potential faults in manufacturing processes before they reach the customer and in product and service areas.

The following are the stages of the FMEA process [7] :

1. Identify the function of the production process.
2. Determine the possible *failure modes* of the production process.
3. Determine the potential impact of failure.
4. Determine the causes of defects in the production process.
5. Determination of production process identification method.
6. Determination of *severity* (S), *occurrenceancy* (O), and *detection* (D) values in the production process.
7. Look up the RPN Value

Risk Priority Number (RPN)

RPN is an indicator of the severity of the effect (Severity), the probable cause of failure associated with the effect (Incident), and the ability to detect failure (*Detection*). The RPN value is obtained by the following calculation:

RPN = S*O*D

This value is used to identify significant risks to guide corrective actions so that improvement priorities can be made based on the highest RPN value. [10]

Severity (S)

Severity is the first step in risk analysis, calculates the risk value, impact/intensity of events affecting the process, scales the impact score from 1 to 10.

Table 1*Severity* Value Criteria

Effect	***Severity Effect for FMEA***	***Ranking***
Low	*Failure for which there is no immediate effect*	*1-3*
Currently	*Defects can still be repaired*	*4-6*
High	*There are many types of defects*	*7-8*
Very High	*Doing work from scratch, causing the machine function to be interrupted*	*9-10*

Occurance (O)

Occurance The probable origin of the cause is shape distortion during the production process. On a scale from 1 to 10, each rating has its own criterion.

Table 2*Occurance* Criteria

Effect	***Occurance Effect for FMEA***	***Ranking***
Low	*little number of defects*	*1-3*
Currently	*one failure*	*4-6*
High	*Repeated Failure*	*7-8*
Very High	*Irreplaceable Failure*	*9-10*

Detection (D)

The detection score is related to the control current, total controllability or control failure.

Table 3*Detection* Criteria

Effect	***Detection Effect for FMEA***	***Ranking***
Almost Impossible	*The controllers can hardly carry out causal detection*	*10*
Very Remote	*The inspector cannot detect failures*	*9*
Remote	*The controller is very difficult to detect the cause of failure*	*8*
Very Low	*problem detection very weak*	*7*
Low	*problem control ability of detection is weak*	*6*
Moderate	*moderate failure detection control*	*5*
Moderately High	*Controller error causes the detection ability to be quite high*	*4*
High	*The ability of the controller to detect the cause of failure is high*	*3*
Very High	*High controller error results in very high detectability*	*2*
Almost Certain	*Current controllers are almost certain to detect the cause of the failure*	*1*

Proposed improvements

This proposal is used to examine the problems encountered. From the results of these determinations obtained results that can be used to solve the problem. [2]

Results and Discussion

Table 4Data on Welding Defects in May – June 2022

Year	*Weeks*	*Number of Welding Points*	*Welding Defects*									*Number of Defects*
			Spatter	*Overlap*	*Porosity*	*Undercut*	*Incomplate fusion*	*Slag*	*Bad String Bead*	*Start stop*	*Pin Hole*	
2022	*1*	*30*	*2*	*3*	*2*	*4*	*5*	*2*	*4*	*2*	*2*	*26*
	2	*28*	*3*	*2*	*5*	*3*	*2*	*3*	*3*	*2*	*2*	*25*
	3	*25*	*2*	*2*	*1*	*2*	*6*	*2*	*2*	*1*	*4*	*22*
	4	*35*	*5*	*3*	*4*	*1*	*4*	*5*	*2*	*-*	*2*	*26*
	5	*35*	*2*	*3*	*5*	*4*	*5*	*-*	*4*	*2*	*-*	*25*
	6	*30*	*3*	*4*	*3*	*1*	*2*	*2*	*3*	*4*	*3*	*25*
	7	*38*	*1*	*-*	*1*	*2*	*-*	*5*	*2*	*4*	*3*	*18*
	8	*25*	*3*	*2*	*2*	*5*	*2*	*-*	*5*	*1*	*3*	*23*
	Total	*246*	*21*	*19*	*23*	*22*	*26*	*19*	*25*	*16*	*19*	*190*

In Table 4 above is research data on weld defects carried out in May - June 2022, data was taken visually and hydrotested on the feed drum project carried out at PT. Swadaya Graha. Based on these types of defects, research is carried out to determine the causes and consequences of each defect that occurs during the production process of the feed drum project and *control to detect* the *causes* of failures that occur. 5 below.

Table 5 FMEA analysis for each type of disability.

Defect	*Failure effect*	*S*	*Failure Cause*	*O*	*Control*	*D*	*RPN*
Spatter	Improper Electrode movement speed	6	Welding arc too far	7	Adjust the distance of the welding arc on the material, so that the speed can be stable	5	210
Overlap	The size of the weld is over the	5	Incorrect welding movement	6	Provide enough space during the process	6	180
Porosity	Porous welds	6	Welding conditions that are too humid	8	Reducing Moisture and cleaning the material	7	336
Undercut	Electrode swing when welding is irregular	5	Operators do not master the machine	5	Improve operator capabilities	5	125
Incomplate Fusion	Welding results are not perfect	6	Incorrect welding wire angle position	8	Fixed the angle position of the electrodes	8	384
Slag	Flux in the weld area and melting	9	The seam angle is too small	7	Welding angles must match	6	378
Bad String Bead	The shape of the groove is wavy	7	The electrode movement is too large	6	Improve operator capabilities	4	168
Start Stop	Improper weld line connection	8	Too many electrode wire refills	5	Check the power supply and stand holder.	8	320
Pin Hole	Formation of gas during welding	6	Less clean material	7	Weld according to WPS R	5	210

Source: various welding defects [11]

The results of the assessment and the results of data analysis regarding all types of defects are in table 2. The SOD values were taken from the results of interviews with 2 inspectors from the *quality control section of the feed drum* project, 1 *welder* and 1 *helper* at Pt. Swadaya Graha. The results of this assessment obtained RPN values for each type of *defect* . For this type of welding defect *Spatter* gets an RPN value of 210 based on the multiplication value of *Severity* (6), *Occurance* (7) and *Detection* (7). *Overlap* welding defects get an RPN value of 180. Based on the multiplication of *Severity* (5), *Occurance* (6) and *Detection* (6). The third type of weld defect, namely the type of *Porosity defect,* gets an RPN value of 336. The results of the *Severity* (6), *Occurance* (8) and *Detection* (7) calculation values. In the fourth type of weld defect, namely the type of *Undercut defect* , the RPN value is 125. The result of the multiplication of *Severity* (5), *Occurance* (5) and *Detection* (5). In the fifth type of weld defect, namely the *Incomplate Fusion type of defect,* the RPN value is 384. The results are multiplied by *Severity* (6), *Occurance* (8) and *Detection* (8). In the sixth type of weld defect, namely the type of *Slag defect* , the RPN value is 378. The calculation value for *Severity* (9), *Occurance* (7) and *Detection* (6). The seventh type of weld defect, namely the *Bad string Bead defect type,* gets an RPN value of 168. The value is from *Severity* (7), *Occurance* (6) and *Detection* (4). In the eighth type of welding defect, namely the *Start Stop type of defect* , the RPN value is 320. The results of the *Severity* (8), *Occurance* (5) and *Detection* (8) calculation values. In the last type of weld defect, namely the *Pin Hole defect type,* the RPN value is 210. The result of the multiplication value is *Severity* (6), *Occurance* (7) and *Detection* (5).

After determining the causal factors and consequences of each type of welding process defect and also calculating the RPN, the next step is to determine the ranking of the highest value of the type of welding defect that gets the most critical value or defect value in the production process of the *feed drum project* .

Table 6 Ranking of RPN Points

No	*Welding Defect*	RPN	Ranking
1	*Spatter*	210	7
2	*Overlap*	180	5
3	*Porosity*	336	3
4	*Undercut*	125	9
5	***Incomplate Fusion***	**384**	**1**
6	*Slag*	378	2
7	*Bad String Bead*	168	6
8	*Start Top*	320	4
9	*Pin Hole*	210	8

In this table are the RPN values for all types of welding defects. For overcome consequence the so based on type disabled weld Which own mark RPN most tall, so that No bother operational company. Operation correct disabled weld given ranking from mark RPN highest until Lowest, that is Which First is *incomplete Fusion* with value 384. , the second *slag* welding defect with a score of 378, the third *Porosity* with a score of 336, the fourth Start Stop with a score of 320, the fifth *Spatter* welding defect with a score of 210, the sixth *Pin Hole* welding defect with a score of 210, the seventh *Overlap* welding defect with a score of 180, the eight *Bad String Bead* welding defects with a score of 168 and the welding defect that has the lowest score is *Undercut* with a score of 125.

Based on the analysis and evaluation of these types of errors and determining the RPN value, the next step is to design an improvement plan to eliminate these types of errors. For the type of error with the highest RPN value, some suggested improvements are made to eliminate the error.

Proposed Improvements

Based on the results of FMEA and analysis of failures which resulted in many defects in the welding process , there are several suggestions for improvement from the author regarding this matter, namely:

- The company can check the welding machine periodically so that the machine will used on the production process No own obstacles. Make a maintenance schedule for tools used for the production process in top condition.

- Companies can practice in a manner gradually, that is twice a year. This is done to improve the quality and skills of operators. Companies can offer training repeat For equip operators with necessary skills _ For handle change request work as well as desire customer. In training this, employee will get explanation And instruction operation machine, manufacture pattern basic, QC knowledge, training welding And position welding For avoid process failure.
- Companies are required to recruit welding operators who have expertise and knowledge about the types of welding processes and welding positions and provide strict supervision of welding operators so that the performance of operators in the production process can be better, and impose sanctions on operators who lack discipline.

Conclusion

The following results were obtained in this study : First , the nature defects in the welding process at Pt. Self-subsistent Graha, that is *undercut, spatter, overlap, incomplate fusion, porosity, pin hole, stop start and slag,* yield show that type disabled fusion No complete more preferred during inspection And repair Because own mark highest. Mark RPN with score 384. Company expected quick repair constraints that exist in order for the company can increase quality the product.

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