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Analysis of crack defects in the hanger welding area using the DMAIC method in the heavy equipment industry

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ABSTRACT

Heavy Equipment Industry is a company operating in the mining heavy equipment industry. The Quality Control Department continues to strive to maintain and improve the quality of every product produced. During 2022 there were complaints from customers, where there were 7 complaints about hangers detaching from the frame. The hanger is a connecting component between the leaf spring and the chassis which functions as a support for the load. This has a very fatal impact because it is related to safety, unit function and unit productivity. The crack defect caused a repair process by re-welding the part of the hanger where the crack was present. The aim of this research is to reduce the defect rate in Hanger defects. The method used is DMAIC. Primary data and supporting data were collected through field observations to describe actual conditions before repairs. Based on the results of the analysis and improvements that have been carried out, it was found that creating work instructions for the process of attaching hangers to units can help manpower understand the process and work sequence in hanger fabrication. The proposal to add reinforcement check points to the hanger setting check sheet is hoped to be able to maintain the hanger without reinforcement entering the next process and increase supervision of the hanger welding quality.

Keywords: Defect crack; hanger welding; DMAIC method

1. INTRODUCTION

The development of the industrial sector in Indonesia has experienced quite rapid development in recent years [1]. Likewise, the construction industry sector is listed as one of the business fields that shows positive performance improvements amidst slowing economic growth [2]. The growth of the heavy equipment industry has experienced good development and grown significantly. This is known from the competitive market share of the heavy equipment industry [3].

One of the companies operating in the construction services industry is the Heavy Equipment Industry. Heavy Equipment Industry is a company located in Tangerang City, Indonesia which operates in the general contracting sector. Construction activities cannot be separated from heavy equipment as work support. Completion of a particular job or part of a project requires tool selection where the selection of heavy equipment depends on the characteristics of the tool and terrain conditions. This is necessary so that the tool can work optimally so that the work can be completed on time at the lowest possible cost. The Quality Control Department continues to strive to maintain and improve the quality of every product produced, including the fabrication process. Fabrication is the process of processing material components that are assembled and formed into a series of production tools or technical structures that provide added value based on certain factors. Fabrication is related to the welding process. During 2022 there were many complaints about the hanger. The crack defect led to a repair process by re-welding the part of the hanger where the crack was present. It is important to carry out research to reduce crack defects in this area.

Based on previous research, to overcome defects using the DMAIC method [4]–[6]. DMAIC method is sequential and scalable [7], [8]. This method is often used in the Manufacturing Industry [9]–[11]. Successful application in the manufacturing industry cannot be separated from significant quality improvements [10], [12]. The DMAIC method is often combined with Six Sigma [13], [14]. This research will apply the DMAIC method in the heavy equipment industry. The aim of this research is to reduce the defect rate in Hanger defects

2. METHOD

This research was conducted in the Indonesian Heavy Equipment Industry. Research focuses on reducing reject rates in hanger welding. The method used is Define, Measure, Analyze, Improve and Control (DMAIC) [15], [16]. DMAIC is a systematic approach and focuses on quality [17], [18], [19]. The primary data used is the result of direct observations in the hanger welding area, while the secondary data is the result of production for the 2022 period. Data collection using Focus Group Discussions was also carried out with experts [20]–[22]. Analyze the problem using a fishbone diagram [23], [24]. The research stages used by DMAIC can be seen in Figure 1.

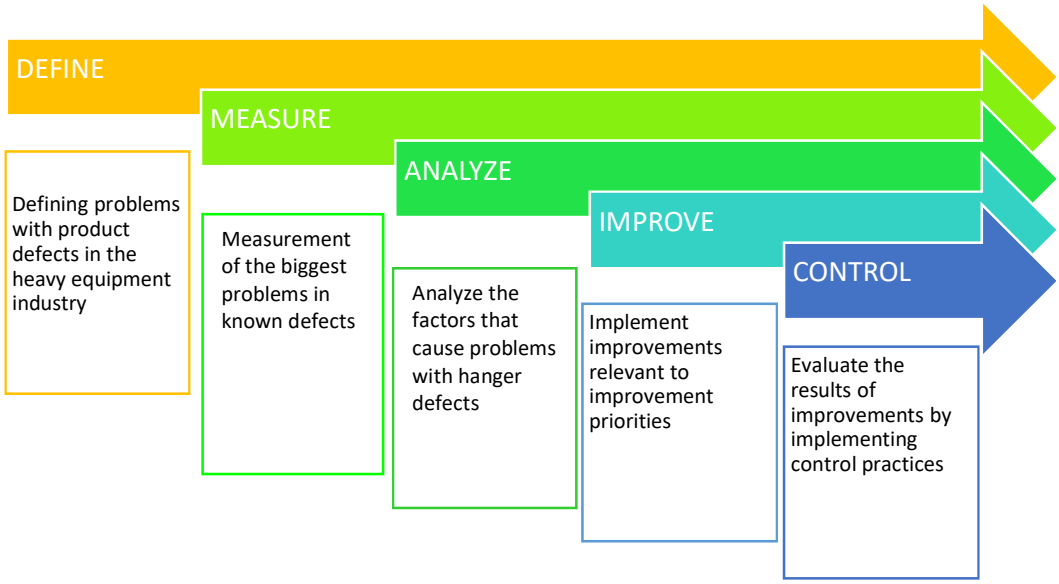

Figure 1. The DMAIC process flowchart

3. RESULT AND DISCUSSION

3.1. Define

For the period January-December 2022, there were 7 cases of complaints about hangers detaching from the frame. The hanger is a connecting component between the leaf spring and the chassis and is the support for the load. The problem that often occurs with hangers is the presence of cracks in the welding connection between the hanger and the bottom flange frame. This has very fatal consequences because it is related to safety, unit function and unit productivity. The crack defect caused a repair process by re-welding the part of the hanger where the crack was present. The following is data on problems that occurred among consumers in the period January – December 2022, which can be seen in Table *1*.

Table 1. Data on problems that occurred among consumers

Type of Unit	Total
Trailer	129
Small-Medium Vessel	39
Big Vessel	26
Small Sufeq	59
Big Supeq	0

Type of Unit	Total
Industrial	13
Other	0
Total	266

Table 1 shows the problems that occur in products based on the type of unit experiencing the problem. Based on the information above, the trailer unit type has the highest problems, namely 129 problems out of 266 problems with a problem percentage of 48.5%.

3.2. Measure

Measure is a stage for validating problems, measuring and analyzing problems from existing data. At this stage, measurements are taken of all the data that has been collected. Based on the various problems that occur to customers on trailer units, below are 20 problems that frequently arise on trailer units based on the problems that occur to customers in 2022, which can be seen in Figure 2.

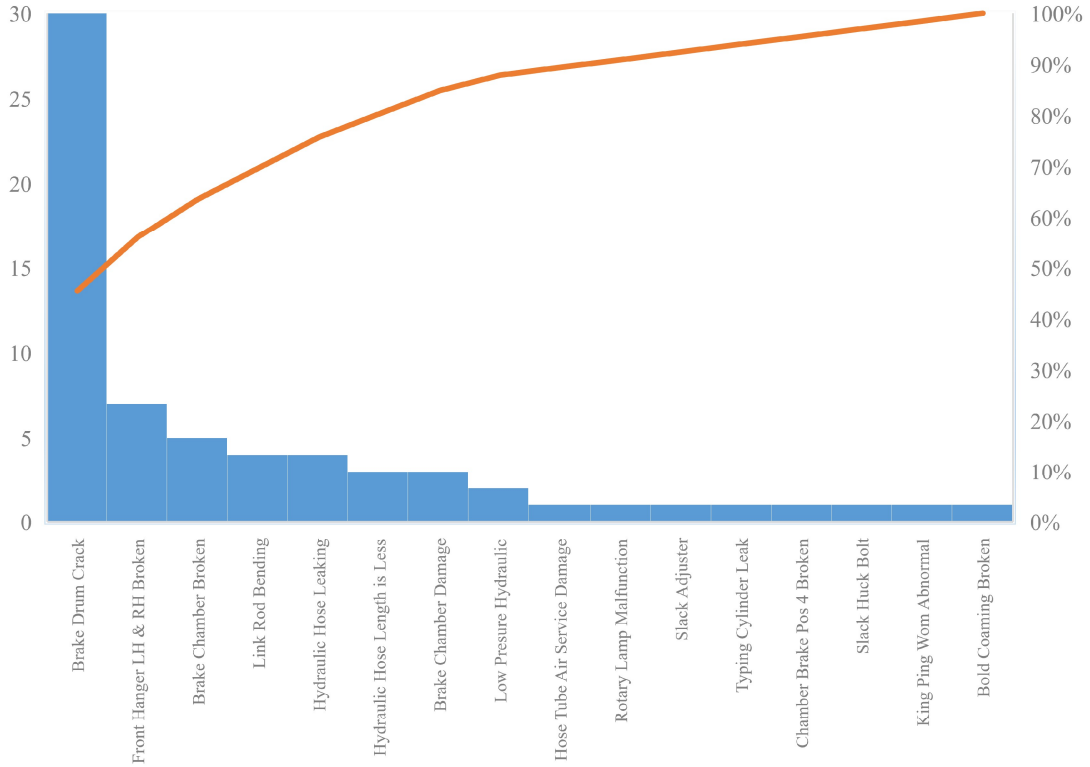

Figure 2. Pareto diagram types of defects

Figure 4 shows the problems that occurred in the unit based on information from claim & complaint reports received by the customer service team during 2022. Based on Figure 4, it is known that the most problems that occurred during 2022 were with the brake drum component, reaching up to 30 cases. in a year. Because the brake drum improvements were carried out by the vendor, this research focused on improvements to the broken fornt hanger.

3.3. Analyze

Meanwhile, after reviewing each claim & complaint report addressed to the broken hanger component, it was found that the problems that occurred with this component were very varied. There are 2 types of problems that occur in the Trailler product group. On the dolly 60, dolly 50 and SST 130 units, problems occurred in the welding area where the hanger cracked and came off the frame in 4 cases. Meanwhile, on the SDT 90 unit there was a problem with the fornt hanger and the fixed torque rod being broken. The following is data related to hanger problems.

Based on the data collection that has been carried out, this section will analyze the causes of the type of broken front hanger problem that occurs in Semi-Trailer Side Tipper (SST) and Dolly units. Based on data on problems that occurred in 2022, defect welding cracks in the hanger area did not occur in all trailer units. This indicates that the problems that occur in the hanger area are not caused by the construction design made by engineering. The hanger defect can be seen in Figure 3.

Figure 3. Hanger welding defect

Based on data analysis of current conditions, the research concludes that the roots that cause crack defects in the hanger welding area are presented in a fishbone diagram. The fishbone diagram can be seen in Figure 4.

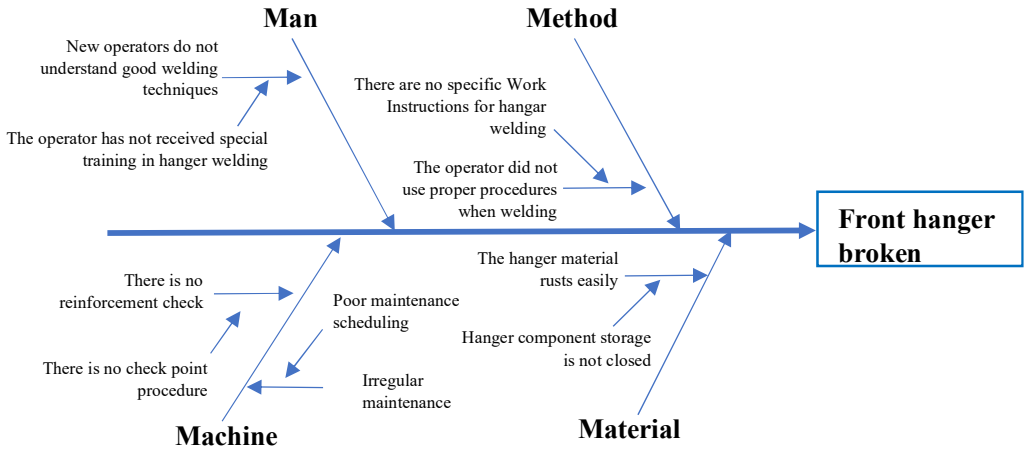

Figure 4. Fishbone diagram of front hanger broken

After finding the root of the problem, a repair plan is then carried out to overcome the problem of welding defects in the hanger welding area so that similar problems do not occur again.

Table 2. 5W+1H for improvement

What	Why	Who	When	Where	How
There are no work instructions regarding the sequence of the process of attaching the hanger to the bottom flange frame	So that no processes are missed and it makes it easier for new personnel to understand the sequence of the process of attaching the hanger to the bottom flange frame	Kaizen Team	July 2023	Plant 2 hanger fabrication	Work instructions were created regarding the sequence of the process of welding the hanger to the bottom flange frame
There is no point check on the hanger setting check sheet regarding reinforcement installation	To make sure the reinforce is installed on the front hanger	Kaizen Team	July 2023	Quality Planning	Added check points to the check sheet related to checking reinforcement
New operators do not	So that operators master	People	July 2023	People	Training or skill up is

yet understand the welding process in the hanger area	welding competence in the hanger welding area	Development Center		Development Center	held regarding the competencies needed in the hanger welding area
Storage of components so that they are not closed	So that the hanger components are exposed to rain and corrosion	Warehouse Dept.	Sep 2023	Plant 2 hanger fabrication	Hanger storage is moved to a closed area
Machine maintenance data records are not updated continuously	So that the welding machine remains in optimal condition when used	Maintenance Dept.	Sep 2023	Plant 2 hanger fabrication	Socialization was held to operators to fill in machine maintenance updates

Based on Table 2 5W+1H, the improvements made only address 2 of the 5 existing root problems. This is because it is outside the scope of the quality control department.

At this time, operators working on the trailer unit fabrication line know the flow of the hanger installation process based on information obtained visually by the previous operator. So the operator does not understand exactly what process should be carried out. In fact, the problem of the hanger detaching from the frame is due to the operator's negligence in not carrying out the process sequence correctly.

Figure 5. Hanger welding work instructions

After analyzing the related problems, a work instruction was created regarding the process of fabricating the hanger to the unit so that there would be no more missed processes when installing the hanger and to make it easier for new operators to understand the sequence of the process of attaching the hanger to the bottom flange frame. The work instruction in Figure 5 explains the sequence of the process of attaching the hanger to the bottom flange frame, there are pictures and descriptions of the process carried out to make it easier to understand the work instruction. Reinforcement installation is included in the work instructions to remind the operator so that this process is not missed again. Detail of work instruction can be seen in Figure 5.

3.5. Control

This stage is the final stage in the DMAIC method, which contains how to control the previous stages so that quality can be controlled. This control is carried out with 4 aspects, namely Safety, Quality, Cost and Delivery

a) Safety

Judging from the safety factor, the problem of the front hanger detaching for consumers is very fatal because the front hanger detaching from the bottom flange can cause the unit to experience an accident so that the unit cannot function. By making repairs during the process of welding the hanger to the bottom flange frame, the problem with the front hanger will not recur

b) Quality

Judging from the quality aspect, with this improvement it is hoped that it can improve the quality of products produced in the Heavy Equipment Industry, especially in hanger welding so that hangers do not crack when the unit is at the customer due to the absence of reinforcement.

c) Cost

It is hoped that with the work instructions that have been created, the quality of welding in the hanger area can be maintained so as to reduce repair costs by the service team. By maintaining the quality of the hanger welding, the company has the potential to save repair costs due to broken hanger welding while at the customer.

3. Delivery

For the delivery aspect, it is hoped that this improvement can produce a process that can simplify manpower. Because if the hanger is broken and detached from the bottom flange frame, a repair process is needed, namely re-welding the hanger to the bottom flange frame which is carried out by the service team. However, after this work instruction is provided, it is hoped that this will no longer need to be done, because the welding process in the hanger area is in accordance with procedures. Based on evaluation of four parameters, namely Safety, Quality, Cost and Delivery, all of them have changed. This is in accordance with the KPIs that have been set by the company. The results of this research have contributed to the company's overall productivity

4. CONCLUSION

Based on the analysis and improvement strategies that have been carried out, the results obtained include that there are work instructions for the process of installing the hanger to the unit so that it can help manpower understand the process and work sequence in hanger fabrication. The proposal to add reinforcement check points to the hanger setting checksheet is hoped to be able to maintain the hanger without reinforcement entering the next process and increase supervision of the hanger welding quality. Update welding machine maintenance data records to keep the welding machine in optimal condition when used. Future research can carry out Quality Control Circle practices to get constant results.

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