Analysis of the quality of wheel chain products at UPT logam Yogyakarta using FMEA method

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Abstract. Product quality measurement is an important aspect of the production process. This study aims to determine the types of defects that often occur and find a recommendation for improvement to CNC machine product of Takamaz GSL 15 at Technical Implementing Unit Metal Yogyakarta. In this study, a Pareto diagram is used for analysis the types of defects. Analysis of priority value regarding severity (S), occurrence (O), and detection (D) characteristics is performed by using *Failure Mode and Effect Analysis* (FMEA) method. Meanwhile, Fishbone is used to analyze more deeply about the potential caused by the type of defect. This study succeeded in finding four types of records on the product; they are cracked *pinhole*, imperfect castings, hole defects on the surface, and minus drain lines. This study recommend to include periodic and ongoing supervision of the metal casting process, make metal *wheel chain* in one production line, use modern equipment or machines, replace the drill bits periodically during *machining* process and replace sandpaper with a softness level according to SOP.

1. Introduction

The rapid development of metal industry sector makes the competition among companies become stronger. To survive, each company is demanded to improve the quality of products continuously. Quality has become a necessity because the customer has expectations increasingly about reliability and reduction of maintenance cost [1]. Quality analysis is needed to get a right quality product [2]. FMEA is one of the most widely used methods for useful risk analysis and has been widely applied in many fields [3]. Some examples of the application of FMEA for product quality analysis can be found, among others in battery fire investigation [4], operation theatre of a Tertiary Care Hospital [5], Automated Storage/Retrieval Systems (AS/RS) [6], information security risk management [7], and Electronic Paper Display (EPD) [8]. FMEA has also been developed by combining it with other methods, for example to risk analysis that had been done by Salah, et.al. [9], used for identification and prioritization of failure modes in a system and planning by Ghoushchi, et al. [10], to avoid the use of traditional RPN which it has been criticized with some weaknesses in Li and Chen [11], to improve of risk assessment in Mangeli, et.al. [12], in risk analysis for occupational safety and health by Mutlu and Altuntas [13], and assessing maritime supply chain risks by Wan, et.al. [14]. Some of the benefits of FMEA are: 1) to improve the quality, reliability, and security of the existing system; 2) to maintain the definition of priorities and

activities on the system; 3) reveal similarities to consider the potential failure of the model and effects on the whole process, to help define potential characteristics which are critical and important; 4) to maintain the right media to prevent failure; 5) to define relevant corrections and preventive actions; and 6) to guarantee and monitor the risk reduction activities [15].
Based on data at UPT Logam Yogyakarta, there are 40% of defective wheel chain products. This problem needs to be solved so that the number of defective products can be minimized. Therefore, it is necessary to analyze the quality of the product to find out the types of defects that often occur. The analysis was performed using the FMEA method.

2. Materials and methods

This research was conducted at Technical Implementing Unit of Metal Yogyakarta with the object of product research produced by Takamaz GSL 15 of CNC machine. The research material is primary data in the form of defect data in a period of 1 month, April-May 2019. During that time, there are machine had broken four times, there are two holidays of Election Day and four national holidays. Quality analysis is carried out in 3 stages included as the analysis of types of product defects, determine the priority value of the characteristics, and find the cause and effect of defective products. The kind of product defects analyzed using the Pareto diagram while FMEA used to the priority value of problem-solving with RPN (risk priority number) tool. The priority value of potential failure modes is explained based on the characteristics of severity, occurrence, and detection [16, 17]. RPN is a result of multiplication between severity, occurrence, and detection. Each of these characteristics has a value with a range of 1-10. The higher value of severity causes the higher the severity, the greater the occurrence of the number causes the higher the chance of a process failure, and the greater the detection the number, the lower the level of reliability to detect a failure in a process. Cause effect analysis was carried out by using fishbone diagram based on 4 categories, such as man, material, method, and machine.

3. Results and discussion

3.1. Analysis of the types of product defects

Based on observations, it obtained defect data respectively from the highest is pin hole crack is in a number of 122 (40.1%) units, 73 (24.0%) units castings are not perfect, 57 (18.8%) units holes on the surface, and the pouring channels minus 52 (17.1) %) units, as shown in Figure 1. While the examples of defective products for each of these types are shown in the Figure 2 to 5.

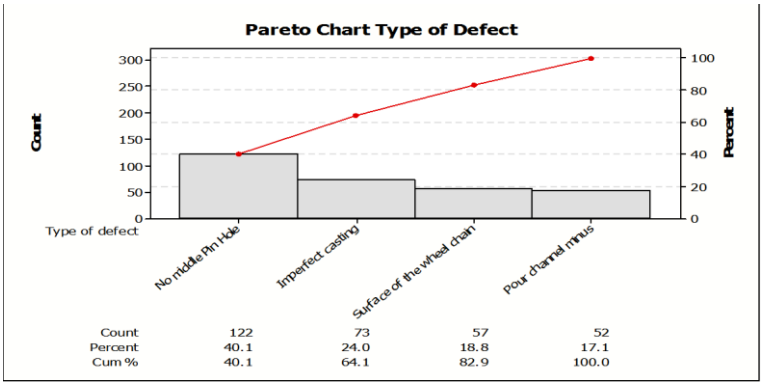

Figure1. The number of defective products in each type of defect

Figure 2. Pinhole crack defective product

Figure 3. Defective products of imperfect casting

Figure 4. Drainage Minus on defective product

Figure 5. Product hole defects on the surface

3.2. Determination of priority value characteristics

Determining priority values is done by explaining the aspects in the severity, occurrence, and detection categories. Priority values for each aspect in a row for severity, occurrence, and detection shown in Table 1, Table 2, and Table 3.

Table 1. Priority values on severity (S)

Nu.	Characteristic	Description	Value
1	None	There is no defective product occur	1
2	Very minor	Only defects that can see profoundly done on the wheel chain	2
3	Minor	Some quality control operators are aware of defects on the wheel chain	3
4	Very low	Operators, quality control, and employees are aware of defects in the wheel chain and continue the machining process	4
5	Low	Operators, quality control, and employees are aware of defects in the wheel chain and do not maintain the machining process	5
6	Moderate	The head of UPT (technical implementing unit) is aware of defects in the wheel chain and does not maintain the machining process.	6
7	High	The machining process is interrupted for 1-2 days	7
8	Very high	There are internal, external and financial disturbances	8
9	Dangerous with notice	Overall defects of more than 75% in the wheel chain	9
10	Dangerous without notice	The machining process of wheel chain stops and endangers employees and the company	10

Table 2. Priority Value of *occurrence (O)*

Nu.	Characteristic	Description	Value
1	None	None defect found on *wheel chain.*	1
2	Very minor	The defect found about 1-10 unit on *wheel chain*	2
3	Minor	The defect found about 15-30 unit on *wheel chain*	3
4	Very low	The defect found about 30-50 unit on *wheel chain*	4
5	Low	The defect found about 50-75 unit on *wheel chain*	5
6	Moderate	The defect found about 75-100 unit on *wheel chain*	6
7	High	The defect found about 100-200 unit on *wheel chain*	7
8	High	The defect found about 200-400 unit on *wheel chain*	8
9	Very high	The defect found about 400-450 unit on *wheel chain*	9
10	Very high	The defect found about 450-500 unit on *wheel chain*	10

Table 3. The priority value of *detection (D)*

Nu.	Characteristic	Description	Value
1	Very high	The control device is capable of detecting defects 100% internal or external factors	1
2	High	The control device can identify the defect 100%	2
3	Moderate	The control device can identify the defect 80-100%	3
4	Moderately high	The control device can identify the defect 60-80%	4
5	Low	The control device can identify the defect 40-60%	5
6	Very low	The control device can identify the defect 20-40%	6
7	Almost impossible	The control device can identify the defect 10-20%	7
8	Almost impossible	The control device can identify the defect 5-10%	8
9	Impossible	The control device is unable to identify defects and does not reach up to 1%	9
10	Impossible	The control device is unable to detect internal or external defects and is not up to 1%	10

Based on *critical to quality* (CTQ), it can be identified that there are four types of defects in the wheel chain. Such as no middle pinhole, imperfect castings, hole defects on the surface, and minus pouring channels. Each type of defect analyze by using FMEA, and the results are sequential - according to Table 4, Table 5, Table 6, and Table 7. The results of FMEA analysis showed that the type of pinhole defect cracked the highest RPN value is 120 in many unusable wheel chain metals (Table 4). The castings defect the highest RPN value is 120 in the metal wheel chain, not straight parallel or symmetrically (Table 5). The hole defects on the surface of the highest RPN value is 144 in making the drill bit not sharp (Table 6). The highest RPN value is 90 on the reduced outer side of the metal wheel chain (Table 7).

Table 4. FMEA on the defect type of *pinhole* crack

Potential failure modes	Potential failure effect	Causes of possible	Value			RPN	Recommendation of Prevention
			S	O	D		
Hole in the *wheel chain* cavity	There are many w*heel chain* unable to be used	The metal has holes, and the mold is not filled	5	6	4	120	Perform supervision and control that is carried out periodically and continuously
The diameter of the hole is not symmetrical or not perfectly round	The *wheel chain* is not straight aligned	The installation of the *wheel chain* refers to the experience of the operator, and the sagging seat is slack	4	4	5	100	Provides training; make SOP according to the project being worked on; conduct regular quality control, machinery, tools, and workers

Table 5. FMEA on the defect types of imperfect mold

Potential failure mode	Potential failure effect	Causes of possible	Value			RPN	Recommendation of prevention
			S	O	D		
Hole in *wheel chain* cavity	*Wheel chain* is not parallel or asymmetrical	There are many *wheel chains* have holes or uneven surfaces. Crust increase or decrease the angle or thickness of the *wheel chain*.	4	3	5	120	Make metal *wheel chain* in one production line or use modern equipment or machines
The size of the *wheel chain* is inconsistent	Angle eroded or scraped after *machining*		4	3	6	72	Perform *wheel chain* continuously measurements before *machining*

Wheel chain molding crust	Adding work phase to clean the metal	Crust lumps on *wheel chain*	4	3	$\overline{6}$	75	Return to the consumer and give step for completing casting again

Table 6. FMEA on the types of hole defect on the surface

Potential failure mode	Potential failure effect	Causes of possible	Value			RPN	Recommendation of prevention
			S	O	D		
The metal of the *wheel chain* does not have any hole	Makes the drill bit not sharp	The drill bit must clash with rough objects	4	6	6	144	Change the drill bits periodically during the *machining* process
The metal of *wheel chain* is not symmetrical	Cannot be processed in the machining stage	Occurs in the *wheel chain* printing process	3	4	5	60	Doing careful observations and create measuring tool assistance
The size of the *wheel chain* is inconsistent	Scraping at metal angles after *machining*	The crust increase and decrease the angle or thickness of the metal on *wheel chain*	4	4	4	64	Replace rough sandpaper with softer or suitable size sandpaper

Table 7. FMEA on the type of minus drain line defects

Potential failure mode	Potential failure effect	Causes of possible	Value			RPN	Recommendation of prevention
			S	O	D		
Metal erosion of *wheel chain*	Reduction in the outer side of *wheel chain*	The metal of *wheel chain* is not symmetrical	3	6	5	90	Change the sandpaper matched to the standard level of smoothness
CNC machine bearings are worn or sagging	Workpieces are tilted and not straight	Lack of checking	4	4	5	80	Perform strict control and supervision

3.3. Cause and effect of defective products

Analysis of the cause and effect of defective products carried out includes cracked pinholes, imperfect castings, holes on the surface, and minus pour channels. It is carried out by identifying that are grouped according to the categories of man, material, method, and machine. The analysis results obtained are then used to describe it in the form of a fishbone diagram. Example of fishbone diagram for many metal wheel chain that cannot be used can be seen at Figure 6.

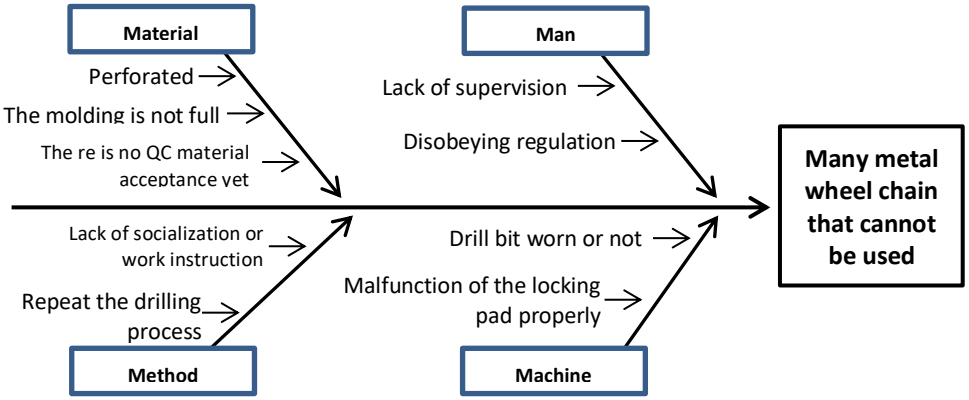

Figure 6. Fishbone diagram of many metal wheel chain that cannot be used

4. Conclusion

This research has been successful in finding four types of product defects that occurred at UPT Logam Yogyakarta. They are such as pinhole cracking, imperfect castings, hole defects on the surface, and minus pouring defects. This study further recommend for conducting periodic and continuous supervision of the casting process metal, making metal wheel chains in one production line, using modern equipment or machines, replacing the drill bits periodically during the machining process and replacing sandpaper with a softness level according to SOP. By using FMEA, the chance of future

defects or failures can be minimized and can identify the impact of defects or process failures. The next subsequent research conducted to calculate the level of product defects to determine whether the number of defective products is still within tolerable limits or not.

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