Analysis of the Production Process Capability of Giboult Joint Products in the Turning Section at PT Aneka Adhilogam Karya

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Abstract

PT Aneka Adhilogam Karya is a manufacturing company engaged in metal casting by producing various types of products including bend, tee, flange, reduce, pipe, manhole cover, collar and one of them is a giboult joint. To maintain the existence of its products, it demands the company to produce quality products. However, it was found that there were 3% of products that had a size deviating from the company's standards when turning where through this process was the determination of the desired size. This study aims to determine the results of process capabilities and provide proposed improvements provided as a solution to reduce deviations in turning giboult joint products using Failure Mode and Effect Analysis (FMEA). The results of the study from the process capability in March obtained Cp values of 1.17 and Cpk 0.54 and April obtained cp values of 1.08 and Cpk 0.52. Then from the failure mode that causes size deviations, the highest RPN value is obtained, namely being exposed to metal powder splashes with an RPN value of 90 so that the precautions taken are the use of protective glasses (safety glasses) on workers in the turning section. Then after the improvement, the results of size deviations were obtained reduced from 3% to 2% and the values of Cp and Cpk increased to Cp 1.27 and Cpk 0.64 so that with the increase in capability, the data that came out of the specification became less and less.

Keywords: Process Capability Analysis, Fishbone Diagrams, Control Maps, Failure Mode and Effect Analysis (FMEA)

1. Introduction

The era of industrial competition requires the industry to produce quality products and have high competitiveness. One of them is the metal casting industry with the development of casting techniques and methods as well as the increase in models of cast products produced. Companies must have superior competitive abilities to maintain the existence of their products in the hands of consumers. Pt. Aneka Adhilogam Karya (AAK) is a manufacturing industry company that was founded in 1968 and is now engaged in metal casting. There are many types of products produced by PT. Aneka Adhilogam Karya, while remaining within the limitations of cast products, namely various drinking water pipe connection equipment (pipe fittings). These types of products include bend, tee, flange, reduce, pipe, manhole cover, collar and one of them is a giboult joint. Giboult joint is one of the water pipe equipment that is useful for connecting long oblong pipes to one another and to close pipe connections so that there is no leakage of clean drinking water pipes.

The giboult joint turning process is one of the most important processes in determining the desired size, namely through the turning and smoothing process at the end of the workpiece until it gets the appropriate size. Based on the data obtained during the turning process, it was found that there were 3% of products that had a size deviating from the company's standard. This size is very important as it functions as a long oblong pipe connection. The quality standards for the size of the product used as a reference have been certified by SNI 07-1769-1990 concerning Connecting Pressurized Drinking Water Pipes from Gray Cast Iron with document number 180/S/RE/B/V/2017. The parameters taken for measurement are the size of the diameter of the giboult joint with the type of PVC 100 set by the company, which is 114 mm with a tolerance ring of ±1.5 mm. The product is said to be good if it has a diameter size of giboult joint, which is at least 112.5 mm and a maximum value of 115.5 mm.

Therefore, an alternative to the existing problems is needed, namely by analyzing the results of process capabilities. Analysis of process capabilities is intended to show that the process is sufficiently capable and produces products that meet the established specifications. Then to identify the priority of the problem that is able to provide suggestions regarding the scale of the most important priorities for handling deviant measures with the aim of reducing existing deviations using Failure Mode And Effect Analysis (FMEA).

2. Literature Review

2.1 Quality

In a production process in reality, there is a discrepancy with the products produced and the products that have been planned. Products that do not comply with existing standards can be said to be defective products. The definition of a defective product according to Hansen & Mowen (2009) is a product that is produced with quality that does not meet specifications. Then the quality according to Marimin (2004) is an *output* that has been produced with a size close to the specified standard.

2.2 Quality Control

Quality control according to Prihantoro (2012) is a comprehensive activity in the management function consisting of quality planning processes, organization, coordination in setting existing policies and controlling resources so that they can meet goals. Starting from the process of *inputting* information or materials until the material enters the factory and is processed in the factory which finally *produces output* and then sent to the customer. This control prevents things from getting worse. For this reason, quality control is defined as supervision of the production process to maintain product standards to match what has been planned and make improvements to existing deviations.

2.3 SPC (Statistical Process Control)

Statistical Process Control (SPC) is a statistical method widely used to determine that a process meets standards. Stated by Montgomery (2009) *Statistical Process Control* is a statistical method used for the collection and analysis of the results of inspections on samples of a production process in supervising product quality. In other words, SPC can be said to be a process intended for standard supervision, paying attention to existing measurements and taking corrective actions against existing deviations during the production of a product. Quality control tools used to overcome various problems during the production process, especially on problems related to quality include *check sheets,* control maps and *fishbone diagrams* (causal diagrams).

a. Check Sheet
   Data collection can be done in various ways, the easiest and most common is to use *check sheets* as stated by Stamatis (2010). *Check sheets* are very widely used because each sheet is simple and systematic for collecting and organizing data.
b. *Control Chart*
   Control chart or commonly called control map is a tool in the form of a process control diagram to determine the upper control limit and the lower control limit of process performance. With a control chart, it can monitor and evaluate problems that exist in a process to determine whether a process is in a stable state or not. One of the variable control maps is the X-R control map obtained from combining the average control map (x-chart) and the range control map (r-chart).
c. Fishbone Diagram (Causal diagram)
   A causal diagram or what is commonly called *a fishbone diagram (fishbone* diagram) according to Heizer and Render (2015) is a tool that identifies process elements or

causes that may affect the results. The use of *fishbone diagrams* is used to show the main causative factors affecting a quality. The main causative factors include materials (raw materials), machines, *man* (labor), *methods* (methods) and the environment.

2.4 Process Capabilities

Process capability is a method that serves to assess the ability of a process to produce a product, by knowing how well the process can produce a product that is in accordance with specifications according to Montgomery (2009). So it can be said that the process ability as a measure that shows a process can produce according to product specifications. According to Andriana (2013) the process ability study aims to determine the ability of the process by producing products that meet the set specification targets before making improvements to a process, preferably a process ability study should be carried out first.

According to Walujo, et al (2020) a process is said to meet the specifications in the requirements, when it is still within the territory or control limit, which is in the normal distribution, which is limited by the lower specification limit and the upper specification limit. Rimantho and Athiyah (2019) explain that there is a time when it says cp *capable value,* does not mean that the process does not produce defects. It is intended that if the process is not target-centric, then one side may come out beyond the specification limit and if it is not centralized, Cp is uninformative because it only pays attention to the distribution of data. In this case, another capability index is used to determine the process ability i.e. Cpk. The process capability index is an index that shows the ability of a process that meets the limit specifications where in its calculations pay attention to the distribution of data and the centering of the process.

According to Walujo, et al (2020), Kayode, et al (2013), Wang, et al (2022) and Yalcin (2022), in the analysis to improve quality, the assessment criteria are used in the process ability for Cp and Cpk values, including:
If the Cp value > 1 indicates the process is still good *(capable)*
If the cp value < 1 identifies a bad process *(not capable)*
If 1 < Cp < 1.33 then the process requires control
If the Cpk value > 1 indicates *that the process performance* is still good *(capable)*
If the Cpk value < 1 then *the process performance* is *not good (not capable)*

2.5 FMEA (Failure Mode And Effect Analysis)

According to Chrysler (2008), *Failure Mode And Effect Analysis* (FMEA) is carried out by identifying and evaluating the source of potential failure or the cause of problems in producing a product then recognizing actions that have the opportunity to reduce potential failures that occur and recording processes (*document the process*). Meanwhile, Gaspersz (2002) stated FMEA as a risk analysis technique whose use is intended to recognize and identify a piece of equipment or system that can fail so that it can have consequences. The FMEA is an analysis where it will be possible to find out related causes and effects and find solutions by taking precautions to describe the best decisions so that appropriate application can be carried out.

3. Methods

The data used as analysis material is the data from the *quality control* diameter examination, including taken in March and April with 20 data samples , each of which was measured 5 times. Here are the steps in the study:

1. Conduct a normality test of diameter measurement data
2. Create an X-R control map by calculating UCL, CL, and LCL.
3. Determine the process capability of Cp and Cpk values
4. Make a fishbone diagram to find out the factors causing the size discrepancy
5. Identify process failures using FMEA
6. Calculate the RPN value and analyze it by making a proposed improvement

4. Data Collection

The data used is standard data on the diameter size of the *giboult joint*, which is 114 mm, with the tolerance ring given by the company ±1.5 mm so that it has a minimum value of 112.5 mm and a maximum value of 115.5 mm. Furthermore, the data from the *quality control* diameter examination in March and April 2022 where there were 20 data samples, each of which was measured 5 times which can be seen in Table 1.

Table 1. Giboult joint diameter measurement data (mm)

Sample Data	Month	Measurement Data					Month	Measurement Data				
		X1	X2	X3	X4	X5		X1	X2	X3	X4	X5
1		114,5	114,7	114,6	115,4	114,9		114,4	114,7	114,9	114,4	115,9
2		115,4	115,2	115,4	114,2	115,7		115,1	114,9	115,3	114,6	114,1
3		114,9	115,1	114,8	116	115,2		114,6	115,4	114,5	114,3	115,3
4		114,6	115,9	114,3	115,4	114,6		114,4	114,6	115,4	114,7	114,6
5		114,7	114,4	114,1	114,9	114,2		114,7	115,4	115,2	114,3	115,2
6		114,3	114,1	115	114,8	114,9		114,3	114,1	114,9	115,2	114,1
7		114,8	114,8	114,6	114,6	114,7		115,4	114,2	115,3	114,3	114,2
8		114,5	114,7	114,9	114,7	114,5		114,2	115,4	115,8	114,6	114,9
9		115,4	115,4	114,2	114,6	115,1		115,3	115,1	114,6	114	114,7
10		114,7	114,7	114	115,4	115,4		114,6	115,3	114	114,1	115,4
11	March	115,3	114,9	115,2	114,5	114,5	April	115,2	114,9	114,8	114,3	115,1
12		114,9	115,3	115,4	115,2	114,8		115,8	114,2	115,1	114,5	114,3
13		115,2	114,6	115,1	114,1	114,3		114,2	114,5	115,4	114,8	114,9
14		114,5	114,5	114,3	114,6	114,9		114,5	115,3	114,1	114,4	114,6
15		115,3	115	114,7	115,3	114,6		114,9	114,6	114,8	115,1	114,5
16		115,1	115,3	114,9	114,7	114,8		114,1	115,4	113,9	114,5	115,4
17		114,3	114	115,3	114,9	114,3		114,6	115,1	114,7	115,2	114,9
18		114,6	114,6	114,6	114,5	114,7		115,4	114,9	114,9	114,5	115,4
19		115,1	114,7	114,5	114,6	114,8		114,8	114,7	114,8	114,8	114,8
20		115,2	114,5	114,1	115,4	114,1		114,5	114,8	114,3	114,1	115,3

(Source: PT Aneka Adhilogam Karya)

Then the FMEA data that has previously been consulted by parties who understand the existing problems to identify potential *failure* modes, the consequences of *failure (failure effect*), causes of failure (cause) and *controls* or preventive measures that can reduce the failure rate.

5. Results and Discussion

The following are the results and discussions carried out in this study..

5.1 Normality Test

Normality test to test the normality of the data, the data is declared normal if it has a significance value of >0.05. Testing was carried out with Kolmogorov-Smirnov using SPSS so that the results could be summarized as per Table 2.

Table 2. Summary of data normality test results

Month	Asymp.Sig Value	Interpretation
March	0,204	Normally distributed
April	0,43	

5.2 Control Chart X-R

Here is the X-R Control Chart for March and April which can be seen in Figure 1 and Figure 2.

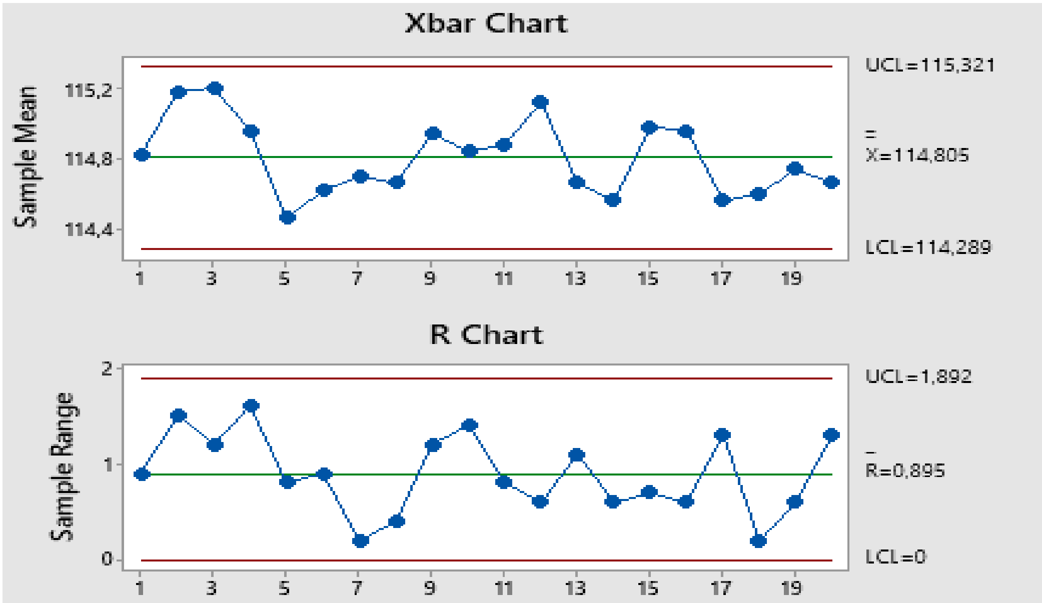

Figure 1. X-R control chart for march

The data pattern that occurs in Figure 1 produces a cyclic pattern. This is the same as Alifia (2018) said explaining that the control maps of Xbar and R show a cyclic pattern which means a gradual shift, with changes there increasing and decreasing. The appearance of such patterns can be caused by the fatigue of workers when carrying out activities. Based on the X-R control chart in March, it experienced several fluctuations. The movement of this cyclic pattern on the *x-chart* reached its breaking point in the 3rd data sample and reached its lowest point in the 5th data sample. Next for *the r-chart*, the 4th data sample reached its peak point followed by the 7th data sample and the 18th reached the lowest point.

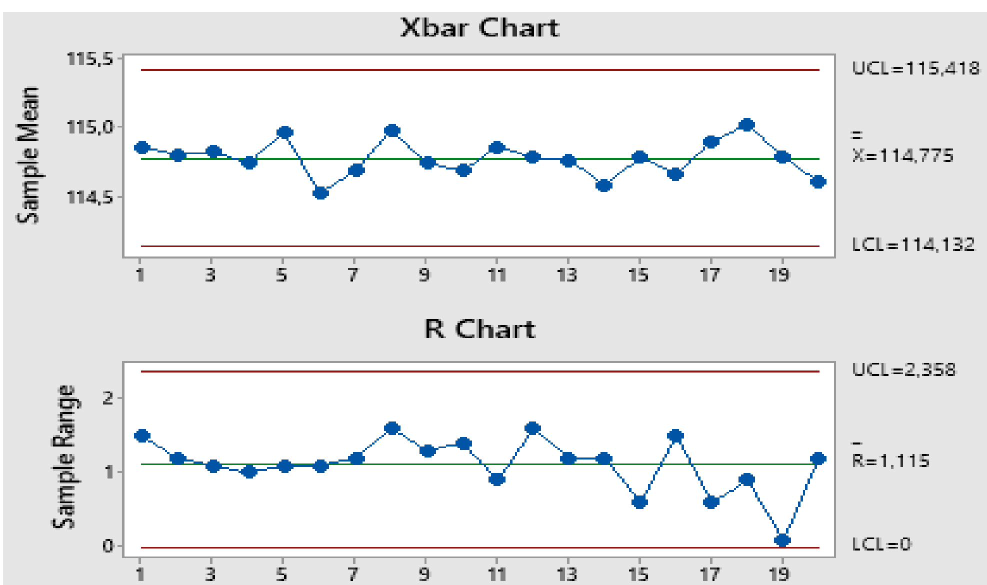

Figure 2. X-R control chart for april

The pattern produced in April is a cyclic pattern that identifies that the turning process has periodic behavior repeatedly as Alifia (2018) said. This pattern can be formed due to causes, among others, due to doing the same work repeatedly so that boredom and fatigue can appear in workers so that there are results that are close to the limit of control.

Based on the control chart, there are several fluctuations, on the x-*chart* that occurs in data samples 1 to 20 where it reaches its peak point for the 18th data sample and the lowest point in the 6th data sample. Furthermore, on the *r-chart*, the 2nd to 7th data samples tend to be close to the CL value. It then reached its breaking point in the 8th and 12th data samples and its low point for the 19th data sample that almost touched the LCL. After ensuring that the control map is in a controlled state, it can proceed to the determination of the capability of the process.

5.3 Process Capability

The standard size of the *giboult joint* diameter is 114 mm, with *an allowance* of ±1.5 mm to have an LSL value of 112.5 mm and a USL of 115.5 mm.

The following process capabilities for March can be seen in Figure 3.

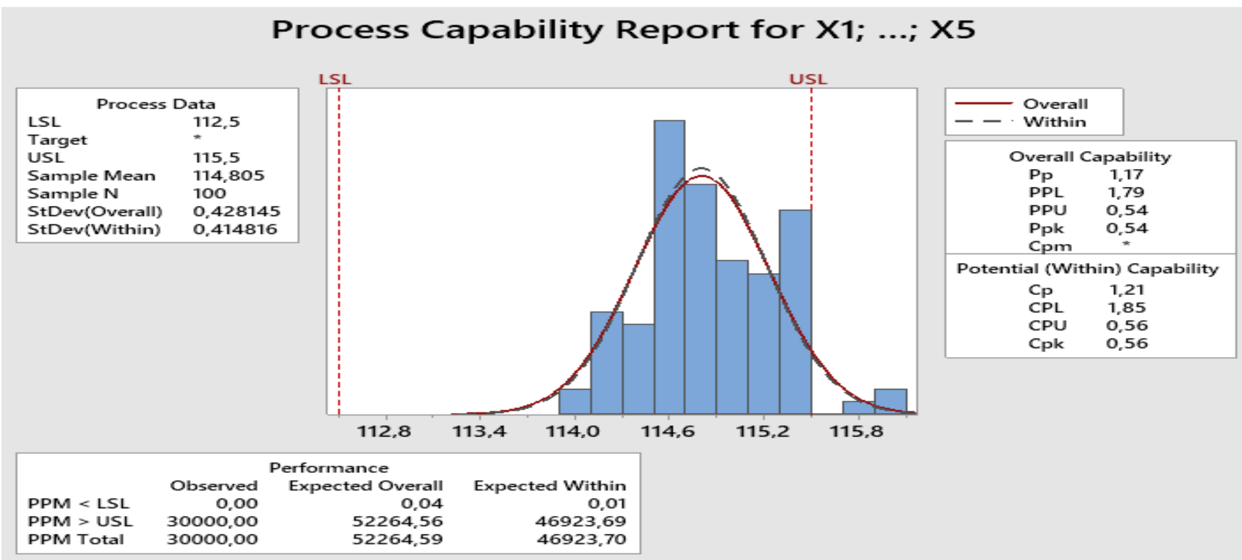

Figure 3. March Cp and Cpk values

Based on Figure 3, the results of the calculation of process capabilities using Minitab 19 *software* for March obtained a Cp value of 1.17 and a Cpk value of 0.54. From these results, it can be interpreted that the turning process is *capable* but still requires control. Furthermore, the cpk value of < 1, which is 0.54, means that the *performance* process is not good because from the results of the identification of control maps that have cyclic patterns, which do the same work repeatedly so that boredom and fatigue can appear.

According to Novitasari (2015) because the value is not yet *capable*, the existing specification limit is smaller than the data distribution so that the process needs to be improved to be appropriate. On the chart, it shows that the distribution of data is more to one side, namely the USL. Meanwhile, from the center of the data, it can be seen that the existing data with the *mean* of the process is not right in the middle, causing the data to be out of the specification limit. Then the determination of the process capabilities for April can be seen in Figure 4.

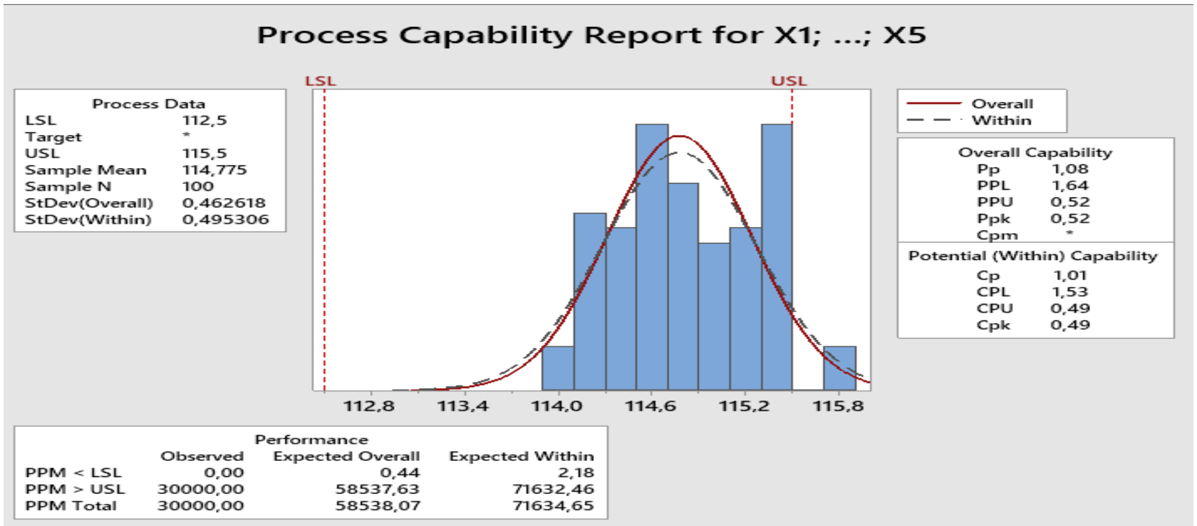

Figure 4. April Cp and Cpk values

Meanwhile, in April, the results of the process capability for cp values were obtained by 1.08 and Cpk by 0.52. It can be interpreted that it *is capable* but still needs control. The result of the Cp calculation resulted in a value of less than 1.33 because it can be seen in the control map pattern, some within a certain period of time. Next from the results obtained, the Cpk value of < 1, which is 0.52, is intended that the *performance* process is not good and not satisfactory enough. Furthermore, the average process is between the specification limits, namely USL and LSL. However, there are still some process variations that are beyond the limits of specifications so it can be said that the process capability is still relatively low as Novitasari (2015) said. This can be seen from the results of the identification of control maps that have cyclic patterns, and are caused by work fatigue. Then, the distribution of data has a tendency to shift towards the USL where the data tends to be more on one right side, namely the USL. Meanwhile, from the data center, it can be seen that the peak is not right on the target so that there is a sample of data that is out of the limit of specifications.

5.4 Fishbone Diagram

By considering several aspects so that 3 causal factors were obtained using the fishbone diagram seen in Figure 5.

1. Environment

   From the lighting, a measurement result of 133.6 lux was obtained. When compared to standards based on the Decree of the Minister of Health of the Republic of Indonesia Number 1405 / MENKES / SK / XI / 2002 concerning Health Requirements for Office and Industrial Work Environments states that the light intensity requirements for rough and continuous work where the work is carried out with machines then have a minimum lighting level of 200 lux. For this reason, it can be said that the lighting has not met the minimum standards and can cause disruption of the production process in terms of vision and production quality.
2. Human

   Workers are determinants of successful performance, especially when they still need an operator to operate the machine. Mr. Darmono who is already 59 years old where the age factor in workers affects fatigue in workers. This is reinforced by Budiman, et al (2016) which contains a relationship between age and fatigue in workers, the older the age, the greater the level of fatigue. Fatigue can cause workers to not reconcile, resulting in their inaccuracy in speeding. With these conditions, it is possible that it can cause size results that deviate from the standard.

In addition, there is another factor, namely workers who are exposed to splashes of metal powder when turning because they do not use protective glasses. This is not in accordance with the Regulation of the Minister of Manpower and Transmigration Number: PER.01 / MEN / 1981 article 4 paragraph (3) which contains that the management is obliged to provide free of charge all personal protection equipment that is required to be used by workers under its leadership for the prevention of occupational diseases. Workers often do not use PPE, one example of which is protective glasses for the reason of being annoying.

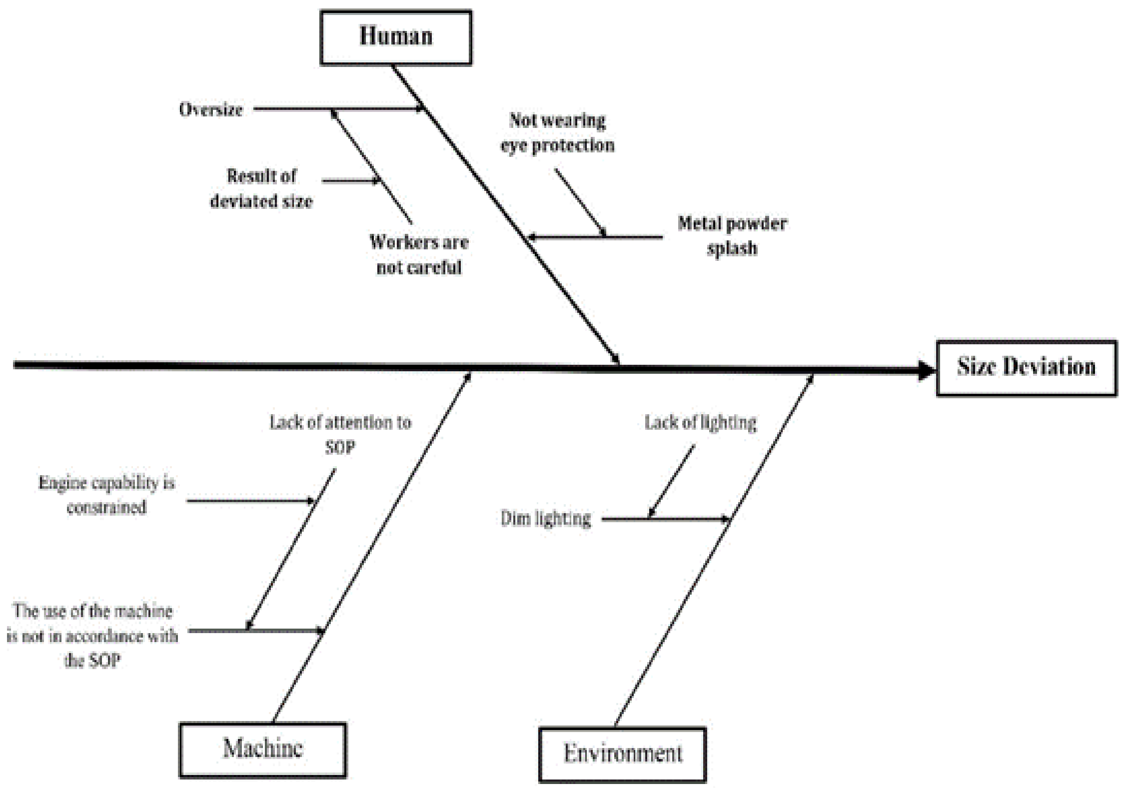

Figure 5. Fishbone diagram deviation size diameter giboult joint

3. Machine
   Mr. Darmono has been working for 33 years. Therefore, workers already feel experienced and skilled but there is *a human error* so that sometimes workers do not pay attention to SOPs. This is reinforced by Fahmi (2016), who said that the longer a person's work period, the more experience they have and mature but there are still those who do not behave safely because they already feel experienced and skilled in doing work. Furthermore, there is a relationship between performance and SOPs, supported by Hidayattulloh and Ridwan (2019) who stated that SOPs have a positive and significant effect on employee performance.
   The effect of worker performance on SOPs will be related to the use of machines that are not in accordance with (Kozlova,2021). This will affect the performance and the results to be achieved are not optimal. According to Damic (2021), national culture also affects the way workers work in a company. National culture is only one of the factors that affects organizations. Formal institutions, customer pressure and the macroeconomic environment also have a significant effect on the organization. These factors can also influence the relationship between ISO 9001 internalization and organizational innovativeness.

Meanwhile, according to Nikolic, et al (2021), to make the organization bigger it is necessary to support the use of software. Software support for this way of applying the SWOT matrix, which mathematically hows the results of the impact, intensity in the interrelationships of factors, should facilitate the application of this analysis and bring it closer to a larger number of organizations.

5.5 Failure Mode and Effect Analysis (FMEA)

The following results of the identification of failure modes found in the turning process can be seen in Table 3.

Table 3. Failure mode and effect analysis (FMEA)

Failure mode (*failure mode*)	**Consequences caused (*failure effect*)**	**S**	**Potential causes (*cause*)**	**O**	***Controls***	**D**	**Rpn**
Dim lighting lamps	Size mismatch	4	Lack of lighting	3	Add lighting	4	48
Fatigue	Work slows down and results are not optimal	4	The age of the worker is more than 40 years old	4	Not fortifying workers	3	48
Exposed to bram (splashing metal powder)	Size missed	6	Not wearing eye protection	5	Using *safety glasses*)	3	90
The use of the machine does not comply with the SOP	The turning process is hampered because there is damage *to machine spare parts*	3	SOPs are not considered	7	Supervise workers	4	84

Suherman and Cahyana (2019) showed that in the production process there is a failure mode that must be repaired. Repairs are made based on the causes of failure that have been analyzed from the FMEA so that the problem is known. From the results of the FMEA identification that has been carried out, the highest RPN value of 90 is obtained, namely being exposed to bram or splashing metal powder so that in these conditions corrective actions can be taken.

5.6 Implementation of Proposed Improvements

The proposed improvement is using protective glasses (safety glasses) on workers in the turning section which is implemented for 10 days. The following is the data from the measurement of diameters after repairs which can be seen in Table 4. From this data, 1 data was found that deviated from the company's standard from a total sample of 50 data so it can be said that 2% deviations occurred after the repair. Next, create the X-R control map, namely Figure 6, and the process capabilities in Figure 7.

Table 4. Giboult joint diameter measurement data after repair (mm)

Sample Data	Measurement Data				
	X1	X2	X3	X4	X5
1	114,3	114,6	114,6	114,1	114,2
2	115,1	114,9	114,8	115,4	114,7
3	114,9	114,6	114,6	114,7	114,8
4	114,4	114,5	115,2	115,3	114,9
5	114,8	114,7	114,5	114,1	114,6
6	114,5	115,4	114,9	114,8	115,3
7	115,3	115,9	115,2	114,7	114,7
8	115,1	114,6	114,6	114,9	114,9
9	114,8	114,9	114,8	114,5	114,3
10	114,1	115,3	114,1	114,2	114,4

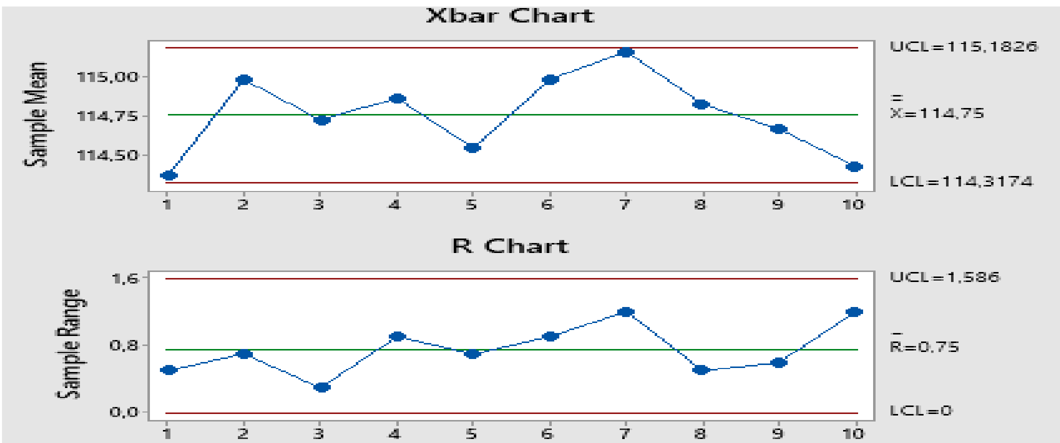

Figure 6. X-R control chart after repair

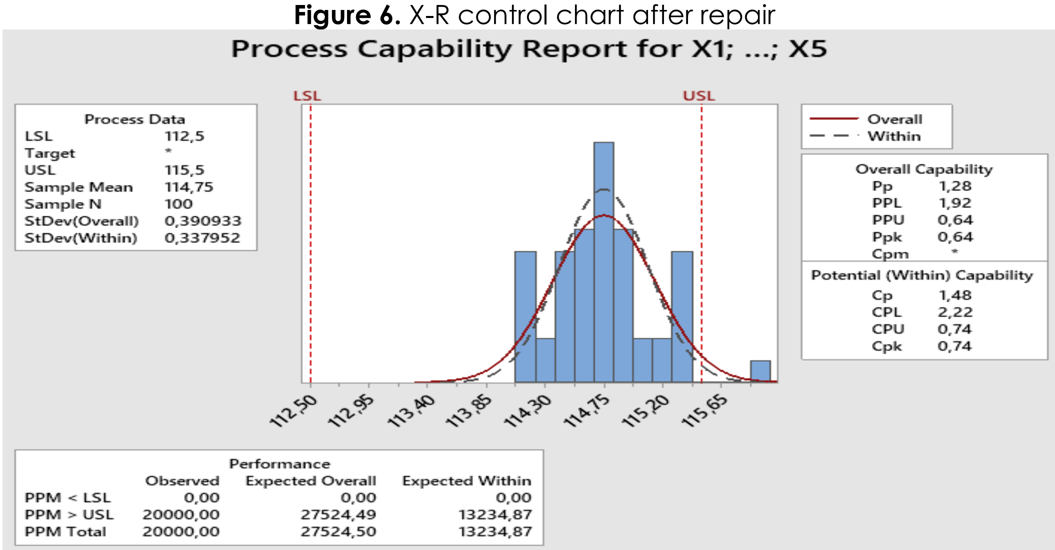

Figure 7. Cp dan Cpk values after repair

Table 5. Comparison of results before and after repair

	Before repair		**After repair**
	March	**April**	
Cp	1,17	1,08	1,27
Cpk	0,54	0,52	0,64

Compared with the results before and after the repair, the result of the deviation in size after the repair was reduced from 3% to 2%. Then the cp and cpk values after the improvement increased, for the Cp value to 1.27 and the Cpk value to 0.64. These results, it shows that the process capability after improvement increases by showing better.

6. Conclusion

The results of the process capability in March obtained Cp values of 1.17 and Cpk 0.54 and April obtained cp values of 1.08 and Cpk 0.52. The results show that the capability is still relatively low With the distribution of data tends to be more to one side of the USL, and the peak is not right on target so there is data that is out of the specification limit. From the results of the FMEA determination, a proposal for improvement was obtained based on the highest RPN value of 90, namely being exposed to metal powder splashes. After improvement, it was obtained that the size deviation was reduced from 3% to 2% and the cp and Cpk values increased, to Cp 1.27 and Cpk 0.64. With these results increasing capabilities, the data from the specification is getting smaller.

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