Quality Improvement Of Bolt Welding M6 X 12 With Six Sigma Method And Multi-Attribute Failure Mode Analysis (MAFMA) In PT. A

Harland Syaefulloh, Rina Fitriana and Elfira Febriani Harahap
Department of Industrial Engineering
Trisakti University
Kyai Tapa No. 1, Jakarta 11440, Indonesia
harlandsyaefulloh@gmail.com, rinaft@trisakti.ac.id, elfira.febriani@trisakti.ac.id

Abstract

PT A is a manufactures high-quality bolts, screws, and keeling nails for widespread use in industry and manufacturing. The production process applied by the company is made to order, where the number of products produced is based on customer demand and specifications from customers. Based on the company's monthly production report, the average percentage of defects for Bolt Welding 6 x 12 is 2.62% where the percentage of defects has exceeded the company's disability tolerance limit of 2%. Solving disability problems can be done using the Six Sigma method with Define, Measure, Analyze, Improve, and Control (DMAIC) stages to improve the quality of production. At the Define stage, SIPOC Diagrams are created and critical to quality (CTQ) determinations are made. At the Measure stage, control map calculation, DPMO calculation, and sigma level are performed. At the Analyze stage, a Pareto Diagram was created to find out the most dominant causes of disability, an Ishikawa diagram to find out the root cause of the most dominant disability problem, and MAFMA method to know the main problem of disability causes prioritized to be fixed based on the greatest weight. At the Improve stage brainstorming is done to increase effectiveness and productivity. At the Control stage, an evaluation of the improvement process has been implemented. DPMO value after the implementation of improvement of 6100 with sigma level of 0.0263 so that it can be known that there is an increase of 0.0263 from sigma level before the implementation of improvement.

Keywords

Six sigma, Critical to Quality (CTQ), Failure Mode and Effect Analysis (FMEA), Multi-Attribute Failure Mode Analysis (MAFMA).

1. Introduction

PT A is a company that produces high-quality bolts, screws, and rivets for widespread use in industry and manufacturing. The production process applied by the company is made to order, where the number of products produced is based on customer demand and specifications from customers. There are 80 product variants by dividing them into six product categories, namely bolt socket, bolt welding, hexagonal bolt, stainless bolt, tapping screw, pin, and rivet. With the number of product variants produced in large quantities, it is inevitable that in producing products several defective products do not meet the specifications set by the company. The method that can be used for quality improvement is the Six Sigma method with the DMAIC stage. Therefore, the purpose of this study is to improve the quality of Bolt Welding M6 x 12 and minimize disability by knowing the highest disability risk priority number (RPN) value and the highest weight of the cause of disability based on MAFMA calculations and the right proposed improvements to the problem.

1.1 Objectives

The purpose of this study was to reduce the level of disability and quality improvement on Bolt Welding M6 x 12 using Six Sigma method with steps identify the type of defect of Bolt Welding M6 x 12 product, calculates DPMO values and sigma levels, analyze the causes of defects using Pareto and priority charts improvements using MAFMA, and provide proposed improvements to reduce the percentage of defects from Bolt Welding M6 x 12 products.

2. Literature Review

Quality has different meanings according to experts. Quality is the overall features and characteristics of a product or service whose capabilities can satisfy the needs, either expressly or disguised. Quality is required by each company in producing a product so that the products offered can be accepted by consumers. Therefore, the company needs to prioritize the quality of products to give a good impression to be accepted by consumers. Therefore, quality is one of the most important factors for consumers in the selection of products they want.

Six Sigma means continuous improvement efforts to reduce the diversity or variability of a process that leads to improved effectiveness. The focus of this method is to reduce the variability of quality characteristics as the key to reducing failure or defect rates. In the Six Sigma method there are stages of Define, Measure, Analyze, Improve, Control (DMAIC).

Define, Measure, Analyze, Improve, Control (DMAIC) is a widely structured problem-solving process used in the repair process. DMAIC is often associated with the Six Sigma method and almost the entire implementation of the Six Sigma method uses the DMAIC stage. This stage can be used to solve the source of problems related to quality and process. The first stage of DMAIC is Define, which at this stage is used to define the action plan that must be done to realize the improvement of each stage of the process. The tools used at this stage are SIPOC diagramming and Critical to Quality (CTQ) identification. SIPOC diagrams are used to map the flow of production processes from raw materials to finished products. The second stage in DMAIC is Measure, which at this stage is used to evaluate and understand the current state of the process with a measurement system that uses tools namely p and c control maps, DPMO calculations, and sigma level determination.

The third stage in DMAIC is Analyze, which at this stage will determine the cause of potential defect failure. At this stage has several tools were used namely Pareto Diagram used to know the number of the most dominant types of disability occurs by applying the principle of 80-20, where 80% is the most influential disability as a result, Ishikawa Diagram is used to identify each cause of existing disability based on 5 factors namely man, machine, method, measure, environment, and material. In Five Why Analysis, a question and answer process is conducted with simple questions to determine the root cause of the problem.

Multi-Attribute Failure Model Analysis (MAFMA) is a tool used to eliminate failures in identifying the cause of failures and determined the most potential causes of failure. MAFMA is a combination of the Failure Mode and Effect Analysis (FMEA) method with the Fuzzy Analytical Hierarchy Process (Fuzzy AHP) method. MAFMA utilizes the use of the fuzzy AHP method in the systematic and efficient analysis of the priority sorting process of potential failure causes and in-depth analysis on the preparation of failure aspects in the form of hierarchical structures. Fuzzy AHP is one of the ranking methods which is the merger of the AHP method and fuzzy logic approach. The fourth stage in DMAIC is Improve, At this stage, a proposed improvement is made to the causes of potential failures that cause disability.

3. Methods

The method used for this problem is Six Sigma with the DMAIC stage. At the Define stage, identification of the production process using SIPOC Diagram and Critical to Quality (CTQ) identification is carried out. At the Measure Stage, data processing is carried out with p and c control map calculations, DPMO calculations, and sigma level determination. At the Analyze stage, analysis of the causes of defects in the product is conducted using Pareto Diagram, Ishikawa Diagram, Five Why Analysis, and MAFMA. At the Improve stage, a brainstorming process is carried out in determining the right improvement proposals in fixing the biggest potential cause of failure based on the largest weighting of the final value of the Multi-Attribute Failure Mode Analysis (MAFMA) method. At the Control stage, an evaluation of the improvement process has been implemented. DPMO value after the implementation of improvement of 6100 with sigma level of 0.0263 so that it can be known that there is an increase of 0.0263 from sigma level before the implementation of improvement.

4. Data Collection

The data used is the data of the production and the number of defects during the 15 working days with the sampling taken randomly. In pandemic conditions, the company only works for 15 days in 1 month. Based on observations that have been made, data obtained from observations of the number of production and number of defective products for Bolt Welding M6 x 12 products in the period November 2020 are presented in Table 1.

Table 1 Observation Data

No.	Date	Sample Size	Type of Defective				Amount of Defective
			Burry	Ruptured Head Section	Dirty	Imperfect Thread	
1	02-Nov-20	500	3	0	2	3	8
2	03-Nov-20	500	0	0	3	7	10
3	04-Nov-20	500	2	1	4	6	13
4	05-Nov-20	500	4	3	5	5	17
5	06-Nov-20	500	6	2	4	6	18
6	09-Nov-20	500	4	0	5	2	11
7	10-Nov-20	500	8	1	0	5	14
8	11-Nov-20	500	0	1	3	5	9
9	12-Nov-20	500	2	2	0	6	10
10	13-Nov-20	500	4	1	7	8	20
11	16-Nov-20	500	2	1	3	7	13
12	17-Nov-20	500	2	4	6	4	16
13	18-Nov-20	500	1	5	5	1	12
14	19-Nov-20	500	4	0	5	8	17
15	20-Nov-20	500	0	1	8	0	9
Sum		7500	42	22	60	73	197

5. Results and Discussion

5.1 *Define* Stage

SIPOC diagrams are used to map process flows according to their acronyms Supplier, Input, Process, Output, and Customer. The product that became the object of this study is Bolt Welding M6 x 12 which has the highest percentage of defects based on data on the number of defective products in the period August – October 2020 which is 3.02%. At this stage, a SIPOC diagram is done that serves to describe the production flow of Bolt Welding M6 x 12 from raw materials sent by suppliers, production process, to become finished products. Below is an explanation of the sipoc diagram of Bolt Welding M6 x 12 products: Supplier, is a supplier of raw materials needed to produce Bolt Welding M6 x 12. Input is the raw material needed to run the production process. The process is a production process activity carried out to produce bolt welding products M6 x 12. The production process starts with the heading, rolling, heat treatment, plating, product inspection, and packaging process. Output is the final product and the result of the production process activities. The resulting output is Bolt Welding M6 x 12 products. Customers are the parties who receive output from the previous process. Customer on the manufacture of Bolt Welding M6 x 12 in the form of the relevant department or subcontract part to continue the production process activities. From SIPOC diagrams, it could be identified the critical to quality (CTQ). 4 types of defective are attributed namely burry, ruptured head section, dirty and imperfect thread.

5.2 *Measurement* Stage

At the Measure stage, the calculation of control chart p and c, DPMO calculation, and sigma level is performed. The data used is the data of the production and the number of defects during the 15 working days with the sampling taken randomly.

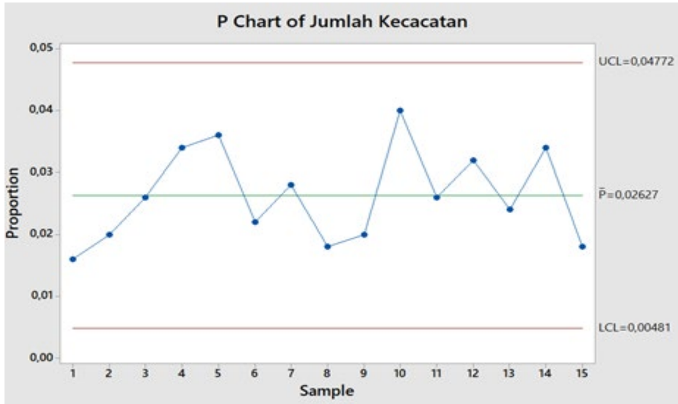

Figure 1. P Chart of Amount of Defective

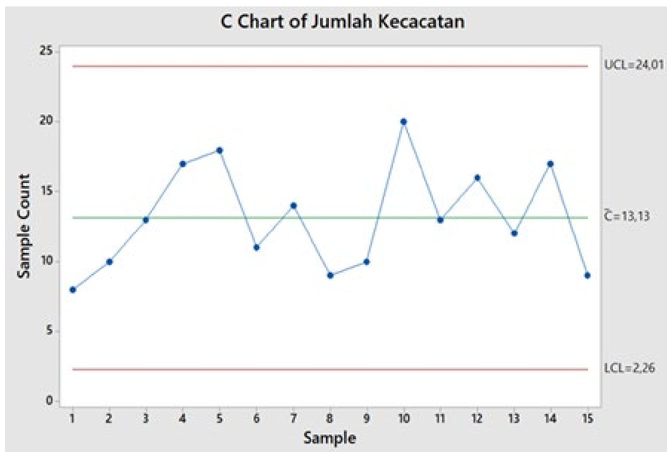

Figure 2. C Chart of Amount Defective

Based on the p and c chart above, it can be concluded that all data is within the control limit of UCL and LCL or in control, then continued with DPMO calculation and sigma level determination. After the calculation, a value of 6567 units was obtained. This DPMO is further converted into a sigma level to 3.98 sigma. DPMO calculation results and sigma level show that sigma level is still far from 6 sigma. This indicates that the increase in sigma level can still be done with quality improvement measures.

5.3 *Analyze* Stage

The analyze stage is the third stage in DMAIC in the implementation of quality improvement using Six Sigma. At this stage, an analysis is carried out based on the defects that occur to find out the cause of the failure and the root cause of the problem to get priority repairs. Pareto diagrams are used to determine the number of the most dominant types of disability occurring. The Pareto diagram used the principle of 80-20, where 80% is the most influential disability as a result of 20% of existing causes.

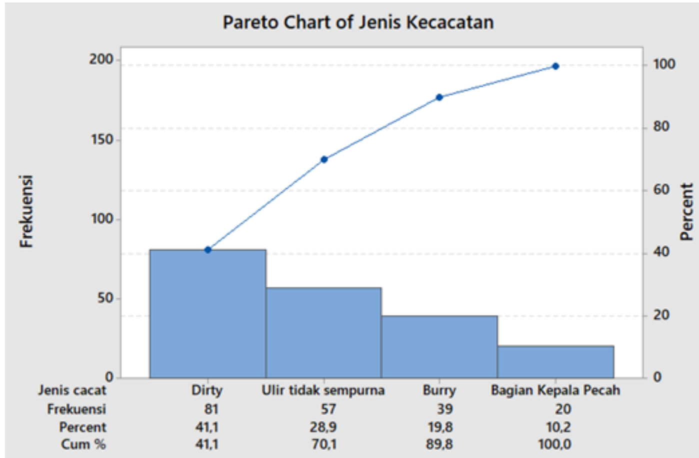

Figure 3. Pareto Chart

Based on figure 3 above, it is known that 80% of the most dominant types of defects occur in Bolt Welding M6 x 12 products, namely imperfect, dirty, and burry threads. Then these three defects are further analyzed using Ishikawa diagrams to find the causes of failure based on 5 factors namely Man, Machine, Method, Measure, Environment, and Material. Ishikawa diagrams for dirty defects, imperfect threads, and burry can be seen in figure 4, figure 5, and figure 6.

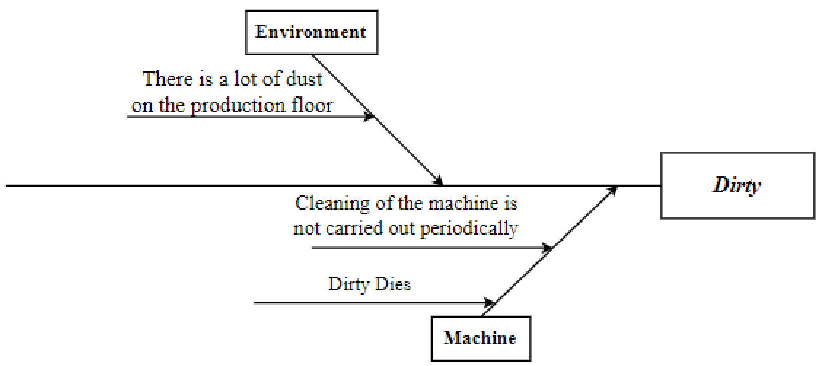

Figure 4. Fishbone Diagram of Dirty

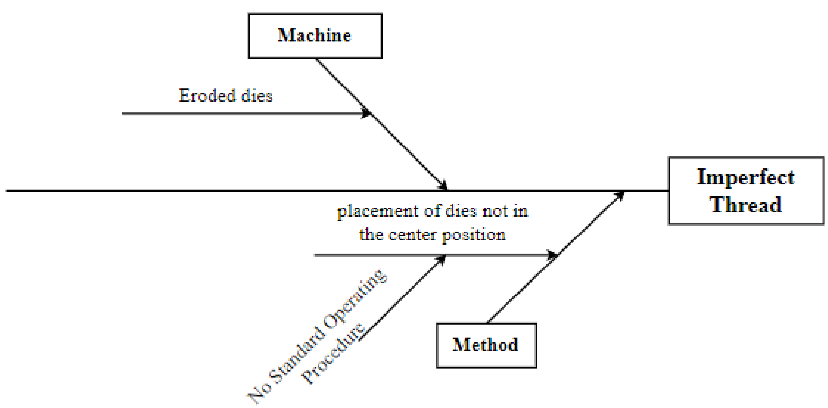

Figure 5. Fishbone Diagram of Imperfect Thread

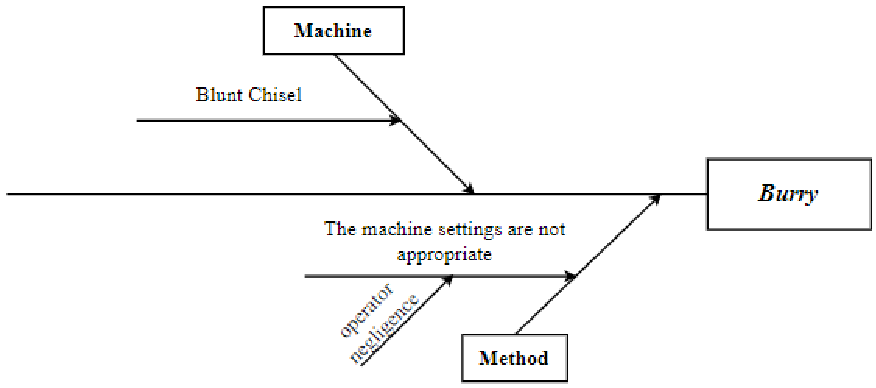

Figure 6. Fishbone Diagram of Burry

After the description of the cause of disability, then continued with the investigation of the root cause of the problem using five why analysis which can be seen in table 2.

Table 2. Five Why Analysis

Defective	***why* 1**	***why* 2**	***why* 3**	***why* 4**	***why* 5**
Dirty	There are spots of dirt on the of the bolt	The formation of the head of the dies bolt is not appropriate	Dirty dies		
		Banyak debu di lantai produksi			
		Dirty Machine	Lack of maintenance	Cleaning is not done periodicallu	
Imperfect Thread	Thread shape does not meet specifications	Dies are no longer optimal	Dies are eroded during the rolling process	*Dies* aus	
		Dies tidak menempel pada sisi lainnya	Dies are not parallel to the other dies	Wrong dies placement	Dies position not in center position
Burry	Cutting on uneven bolt	Chisel are not strong	Chisel are not sharp	Blunt chiseled	
		The pressure on the machine is not optimal	Incorrect machine settings	Improper engine settings	

Once the root cause of the problem is obtained, it is continued by creating a failure mode and effect analysis (FMEA) table. FMEA is used to identify the cause of potential failure as well as assessment of 3 factors, namely severity, occurrence, and detection. In the FMEA table, there is also a risk priority number (RPN) used to determine the priority of a potential process failure by multiplying the severity, occurrence, and detection values.

Table 3. Failure mode and effect analysis (FMEA)

No.	Proses	Failure Mode	Potential Effects of Failure	S	Potential Causes of Failure	O	Current Control for Prevention	D	RPN
1	Heading	Burry	Uneven crop result	7	Blunt chiseled	4	Perform blunt chisel replacement	4	112
			Cut size does not meet spesification	7	Heading machine setting is not in accordance with the provisions	5	Checking the setting of the heading machine	3	105
		Dirty	Reduce the aesthetic value of product	6	There is a lot of dust ont the production floor	5	Cleaning the production floor area	3	90
				6	Dirty dies	6	Regular checking of oil on the engine	5	180
				6	Cleaning of the machine is not carried out periodically	5	Perform regular cleaning of the machine	4	120
2	Rolling	Imperfect Thread	Thread is not full or less than 12 mm	8	Eroded dies	7	Replacing wear dies with new dies	6	336
			No thread on product	8	Placement of dies is not in the center position	6	Checking the postion of dies by the operator before the product process takes place with supervision by the supervisor	5	240

Referring to the calculation of the RPN value in table 3, it is known that the highest RPN value is an imperfect thread on the effect caused by the thread is not full or less than 12 mm with a value of 336. The seven potential causes of failure on this FMEA table will be used in the MAFMA method which will be used as an alternative to the selection of the cause of failure. The Multi-Attribute Failure Mode Analysis (MAFMA) method utilizes the Fuzzy Analytic Hierarchy Process (Fuzzy AHP) method in determining the weight for each cause of failure. MAFMA method integrates conventional aspects of FMEA namely severity, occurrence, and detection with economic aspects so that it can be seen the influence of the cause of failure on costs. Alternatives used based on FMEA are blunt chisel eyes, setting the heading machine is not following the provisions, there is a lot of dust on the production floor, dirty dies, cleaning of the machine is not done periodically, dies to wear, and the placement of dies is not in the center position.

After the creation of a hierarchical structure, the next stage is the creation of a comparison matrix in pairs between criteria and a matrix of comparisons between alternatives expected to cost. In the creation of the matrix, the assessment was conducted with discussions with the managerial side of the factory's quality control division. Table 4 and Table 5 show a matrix of comparisons of pairs between criteria in fuzzy numbers and a matrix of comparisons of pairs between alternatives to expected costs in fuzzy numbers.

Table 4. A matrix in pairs between criteria

Criteria	Severity	Occurrence	Detection	Expected Cost
Severity	(1, 1, 1)	(3, 5, 7)	(1, 3, 5)	(1, 1, 3)
Occurrence	(1/7, 1/5, 1/3)	(1, 1, 1)	(1/5, 1/3, 1)	(1/7, 1/5, 1/3)
Detection	(1/5, 1/3, 1)	(1, 3, 5)	(1, 1, 1)	(1/9, 1/7, 1/5)
Expected Cost	(1/3, 1, 1)	(3, 5, 7)	(5, 7, 9)	(1, 1, 1)

Table 5. Matrix of comparisons between alternatives to the expected cost

Expected Cost	Cause A	Cause B	Cause C	Cause D	Cause E	Cause F	Cause G
Cause A	(1, 1, 1)	(1, 1, 3)	(1, 3, 5)	(1/3, 1, 1)	(1, 3, 5)	(1/7, 1/5, 1/3)	(1, 1, 3)
Cause B	(1/3, 1, 1)	(1, 1, 1)	(1, 3, 5)	(1/5, 1/3, 1)	(1/5, 1/3, 1)	(1/9, 1/7, 1/5)	(1/3, 1, 1)
Cause C	(1/5, 1/3, 1)	(1/5, 1/3, 1)	(1, 1, 1)	(1/5, 1/3, 1)	(1, 1, 3)	(1/9, 1/9, 1/7)	(1/5, 1/3, 1)
Cause D	(1, 1, 3)	(1, 3, 5)	(1, 3, 5)	(1, 1, 1)	(1, 3, 5)	(1/7, 1/5, 1/3)	(1, 3, 5)
Cause E	(1/5, 1/3, 1)	(1, 3, 5)	(1/3, 1, 1)	(1/5, 1/3, 1)	(1, 1, 1)	(1/9, 1/7, 1/5)	(1/7, 1/5, 1/3)
Cause F	(3, 5, 7)	(5, 7, 9)	(7, 9, 9)	(3, 5, 7)	(5, 7, 9)	(1, 1, 1)	(1, 3, 5)
Cause G	(1/3, 1, 1)	(1, 1, 3)	(1, 3, 5)	(1/5, 1/3, 1)	(3, 5, 7)	(1/5, 1/3, 1)	(1, 1, 1)

After creating a comparison matrix for criteria and alternative comparison matrix, each matrix is converted into fuzzy numbers using the Triangular Fuzzy Number scale. The next step is the calculation of the consistency ratio (CR) value of each matrix to find out if the answers or assessments by experts are consistent or inconsistent. Assessment by experts will be considered consistent if the consistency ratio (CR) value is less than 0.1. Once it is known that each matrix is consistent, it is followed by the process of defuzzification and weight calculation for each criterion and alternative.

Table 6. MAFMA Final Value Calculation

Cause of Failure	Final Value MAFMA
Cause A	0,134773673
Cause B	0,111160538
Cause C	0,097338633
Cause D	0,151701127
Cause E	0,103524228
Cause F	0,248388207
Cause G	0,153113595
	1

Based on the final result of the calculation contained in table 6, it can be concluded that the cause of the biggest failure and has the greatest level of improvement importance of other causes is dies wear (Cause F) of 0.248388207. Dies wear can be caused by two factors, namely, the use of dies that have exceeded the standard lifetime that is the use of more than 1 million products, and the lack of oil in the rolling process that can cause frictional force or friction to be high.

5.4 *The Improvement* Stage

The Improve stage is the fourth stage in DMAIC in the implementation of quality improvement. The improvement stage aims to provide proposed improvements to the causes of potential failures selected in the MAFMA method, namely dies wear. Based on the selected failure, a rolling engine oil check form and daily checksheet are created. Dies rolling machine usage. The creation of a rolling engine oil inspection form is made to facilitate the company in the collection of data on the condition of the oil on the rolling machine. Systematic logging makes it easy for operators working to know when was the last time an inspection and actions had been performed on the machine. The creation of this form is expected to prevent the lack of oil in the thread formation process and prevent the occurrence of defects caused by wear and errors.

The second proposed improvement is the creation of a daily checksheet for the use of rolling machine dies. The checksheet is expected to facilitate the painting in the amount of dies usage during the production process will be clear and systematic and prevent the use of dies exceeding the standard lifetime. For standard lifetime usage dies that have been set is 1 million users.

5.5 *The Control* Stage

The Control Stage is the fourth stage in DMAIC in the implementation of quality improvement. At this stage, the implementation of proposed improvements and calculations of control maps, DPMO calculations, and determination of sigma level values based on the data of the implementation of proposed improvements. The results of the calculation before the implementation of the fix and after the implementation of the repair will be compared based on DPMO and the sigma level value to know whether the proposal can improve the quality of bolt welding M6 x 12 products. Below is the calculation of DPMO values and sigma levels after implementation:

Defect per Unit (DPU) = $\frac{Jumlah\ unit\ cacat}{Total\ unit\ yang\ diproduksi} = \frac{197}{7500}$ = 0,02627

Defect per Oppurtunity (DPO) = $\frac{DPU}{CTQ} = \frac{0.02627}{4}$ = 0.006567

Defect Per Million Oppurtunites (DPMO) = DPO x 1.000.000 = 6567

Sigma level = $NORMSINV\left(\frac{1.000.000-DPMO}{1.000.000}\right) + 1,5$

Sigma level = $NORMSINV\left(\frac{1.000.000-6567}{1.000.000}\right) + 1,5$

Sigma level = 3,98 *Sigma*

The calculation result above shows that the DPMO value of the Bolt Welding M6 x 12 product is 6567 units. This DPMO value is then used to obtain the sigma level by converting the DPMO value into sigma level, after the conversion is obtained sigma level of 3.98 sigma which of course can still be increased up to 6 sigma with quality improvement.

6. Conclusion

The DPMO calculation result of the Bolt Welding M6 x 12 production process is 6567 and sigma rate is 3.98 sigma. Based on the FMEA table, the highest RPN value is found in the rolling process on the type of imperfect thread defects with the effect caused is not a full thread or less than 12 mm with a value of 336. The potential failure selected in the Multi-Attribute Mode Effect Analysis (MAFMA) method is dies worn out with a weight of 0.248388207 caused by two factors, namely dies have exceeded the standard lifetime that is the use of more than 1 million products and the lack of oil in the rolling process that can cause friction or friction forces to be high. Proposed improvements to address wear problems are the rolling engine oil inspection form and the daily checksheet of the rolling engine dies.

References

D. C. Montgomary, *Introduction to Statistical Quality Control*, 7th ed. New York: John Wiley & Sons Inc, 2013.

U. Ramly, *Pengendalian dan Penjaminan Mutu*. Jakarta: Penerbit Universitas Trisakti, 2017.

M. N. Nasution, *Manajemen Mutu Terpadu (Total Quality Management)*, Edisi Ketiga. Bogor:Ghalia Indonesia, 2015.

M. Damaindra, A. S. Cahyana, "Peningkatan Kualitas Produk Pada Mesin Produksi Nonwoven Spunbond Dengan Menggunakan Metode Seven Tools Dan FMEA", *Jurnal Spektrum Industri*, vol. 5, no. 2, pp. 245- 255, 2017.

R. Y. Hanif, H. S. Rukmi, S. Susanty, "Perbaikan Kualitas Produk Keraton Luxury Di PT.X Dengan Menggunakan Metode Failure Mode and Effect Analysis (FMEA) Dan Fault Tree Analysis (FTA)," *Jurnal Online INstitut Teknologi Nasional*, vol. 03, no. 03, pp. 137-147, 2015.

N. Nelfiyanti, A. M. Rani, A. Fauzi, "Implementasi Six Sigma Untuk Perbaikan Kualitas Produk Kiwi Paste Berdasarkan Keluhan Pelanggan", *Jurnal Sistem dan Manajemen Industri*, vol. 2, no. 1, pp. 41-52, 2018.

M. Braglia, "MAFMA: Multi-Attribute Failure Mode Analysis," *International Journal of Quality & Reliability Management,* vol. 2, no. 9, pp. 1017-1033, 2000.

D. Hetharia, "Penerapan Fuzzy Analytic Hierarchy Process dalam Metode Multi Attribute Failure Mode Analysis Untuk Mengidentifikasi Penyebab Kegagalan Potensial Pada Proses Produksi," *J. TI Undip*, vol. 4, no. 2, pp. 91-98, 2012.

P. Yuliarty, A. Kholiq, "Peningkatan Produktivitas Produk Screw Pan M5x13MM Pada Mesin JBF-06403 Di Bagian Forming Dengan Metode Define, Measure, Analyze, Improve, Control (DMAIC) (Studi Kasus PT Garuda Metalindo)," *Jurnal Online Teknik Industri ITN Malang*, vol. 8, no.1, pp. 32-37, 2019.

H. Sirine, E. P. Kurniawati, "Pengendalian Kualitas Menggunakan Metode Six Sigma (Studi Kasus Pada PT Diras Concept Sukoharjo)," *Asian Journal of Innovation and Entrepreneurship*, vol. 02, no. 03, pp. 254- 290, 2017.

B. Harahap, L. Parinduri, A. A. L. Fitria, "Analisis Pengendalian Kualitas Dengan Menggunakan Metode Six Sigma (Studi Kasus: PT. Growth Sumatra Industry)," *J. Buletin Utama Teknik*, vol. 13, no. 3, pp. 211-219, 2018.

P. Pangestu, F. Fahma, "Implementasi Six Sigma dalam Peningkatan Kualitas Proses Produksi LED TV di PT Sharp Electronics Indonesia," *J. Performa Media Ilmia Teknik Industri*, vol. 17, no. 19, pp. 152-164, 2019.

A. Santoso, R. Rahmawati, Sudarno, "Aplikasi Fuzzy Analytical Hierarchy Process untuk Menentukan Prioritas Pelanggan Berkunjung ke Galeri (Studi Kasus di Secondhand Semarang)," *Jurnal Gaussian*, vol. 5, no. 2, pp. 239-248, 2016.

R. Fitriana, J. Saragih, S. D. Fauziyah, "Quality Improvement on Common Rail Type-1 Product using Six Sigma Method and Data Mining on Forging Line in PT.ABC," *Journal IOP Conference Series: Materials Science and Engineering*, vol. 847, no. 1, 2020, doi:10.1088/1757-899X/847/1/012038.

Biographies

Harland Syaefulloh is a student in the Department of Industrial Engineering, Faculty of Industrial Technology, Trisakti University, Jakarta.

Rina Fitriana is a lecturer in Department of Industrial Engineering, Faculty of Industrial Technology, Trisakti University, Jakarta. She received her Magister Management Degree from PPM Graduated from Scholl of Management in 2000. She received her Doctoral Degree from Agro-industrial Engineering, IPB. Her research interests are in the area of systems, Management Quality.

Elfira Febriani Harahap is a lecturer in the Department of Industrial Engineering, Faculty of Industrial Technology, Trisakti University, Jakarta. She received her Master of Agro-Industrial Technology from Bogor Agricultural University in 2014. Her research interests are in the area of information systems and design systems. She is a member of the System and Simulation Information.