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Analysis of Patient Bed Product Quality Control with Six Sigma Method and Failure Mode and Effects Analysis (FMEA) (Case Study of PT. Karya Indah Medika)

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A B S T R A C T

PT. Karya Indah Medika is a manufacturing company engaged in the production of hospital furniture. One such product is a patient bed. In each period of patient bed production, there are still defects that occur such as coating defects, dented iron, and broken wheels. The purpose of this study is to determine the percentage of defects, and the causes of defects, and to obtain the greatest risk of failure in the production process in the RPN value so that the type of failure can be determined which should be prioritized first so as soon as possible corrected and determined corrective steps to reduce product defects. The research method used is Six Sigma and Failure Mode Effect Analysis (FMEA). The Six Sigma method includes Define, Measure, Analyze and Improve which will be used to determine the percentage of defects that occur. While the FMEA method is carried out as an effort to improve quality. Based on the research calculations, the results obtained were a sigma value of 3.19σ. Based on calculations using the FMEA method, the largest RPN is obtained for coating defects, namely ink absorption that is not optimal, broken wheel defects, namely operators who are too hasty during assembly, and dented iron defects, inappropriate material quality. Advice that can be given is to control and monitor ink absorption, operators who are more careful and not in a hurry, and check the quality of raw materials before processing.

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1. INTRODUCTION

In the world industry, flawless production is an ideal condition that is always coveted by both producers and consumers who use it. For manufacturing companies, zero defects mean that all waste can be reduced (Dahniar, 2022). Quality issues have led to overall company tactics and strategies to have competitiveness and survive against global competition with other companies. Good quality will result from a good process and following established standards based on market needs (Firmansyah, 2020). Quality improvement is not only done on the final product but also on the process production or still in the production process (work in process), so known defects or errors can still be repaired. PT Karya Indah Medika is a manufacturing company established in 2015 that is engaged in the production of hospital furniture such as patient beds, infusion poles, and others. The production strategy that meets consumer needs is make-to-order (MTO). PT Karya Indah Medika in each patient bed production period there are still problems regarding defects that occur such as coating defects, dented iron, and broken wheels.

Based on the results of interviews that have been conducted, the existence of these defects can be influenced by raw materials, labor, work environment, and others. A large number of uncontrolled defects will result in a sizable nominal loss in the long run, affecting consumer confidence. In the period July – December 2022, PT. Karya Indah Medika produced 392 units of patient beds with 53 units of defects which had a defect percentage of 13.5% so a six sigma value of 3.19σ was obtained. Based on the above problems, researchers conducted research to apply to know the percentage of product defects, and factors that cause product defects, and provide appropriate improvement suggestions to improve the quality of patient bed products at PT. Karya Indah Medika. The Six Sigma method and Failure Mode Effect Analysis (FMEA) are considered applicable to PT. Karya Indah Medika, so appropriate steps can be determined according to what causes defects in the production process at PT. Karya Indah Medika.

2. LITERATURE REVIEW

Quality or quality is the ability of a product, be it goods or services or services to meet the desires of its customers. So that every good or service is always referred to meet the quality demanded by customers through the market. In ISO 8402, quality is defined as the totality of the characteristics of a product that supports the ability to satisfy specified or defined needs. Quality is often interpreted as customer satisfaction or conformity to needs or requirements (Lidan, 2023 The product is considered to be defective due to its characteristics which do not comply with the standards. The characteristics of the quality which are not met by some standards may be associated with defects. Furthermore, products or services may be unacceptably damaged due to the severity of several defects within a product or service.. The modern term for defects is non-conformance, and the term for defects is for items that are not suitable (Fitriana, 2021).

Organizations analyze, monitor, and make improvements to existing manufacturing systems so that the competitive value of products can also increase. Companies or organizations need to maintain the production process and always make continuous improvements so that product quality can be maintained and the resulting product becomes better (Herlambang, 2020).

Quality is a product and service that goes through several stages of the process by taking into account the value of a product and service without the slightest lack of value for a product and service according to high expectations from customers (Angin, 2019). Internally from a cost standpoint within the company. With maintained quality, imperfect component rework costs can be reduced, warranty costs can also be reduced and productivity will increase. Externally from a sales point of view. Good quality will increase the margins obtained by the company by setting higher prices (Harsanto, 2022). In carrying out activities, quality control is a technique that needs to be carried out starting before the production process starts, during the production process, and until the production process ends with producing the final product. Quality control is carried out to produce products in the form of goods or services that are by the desired and planned standards, as well as to improve the quality of products that are not yet by predetermined standards and to maintain the appropriate quality as much as possible (Taufik, 2022). To obtain effective quality control results, a product's quality can be controlled using quality control techniques, because not all production results comply with predetermined standards (Prayudi, 2022).

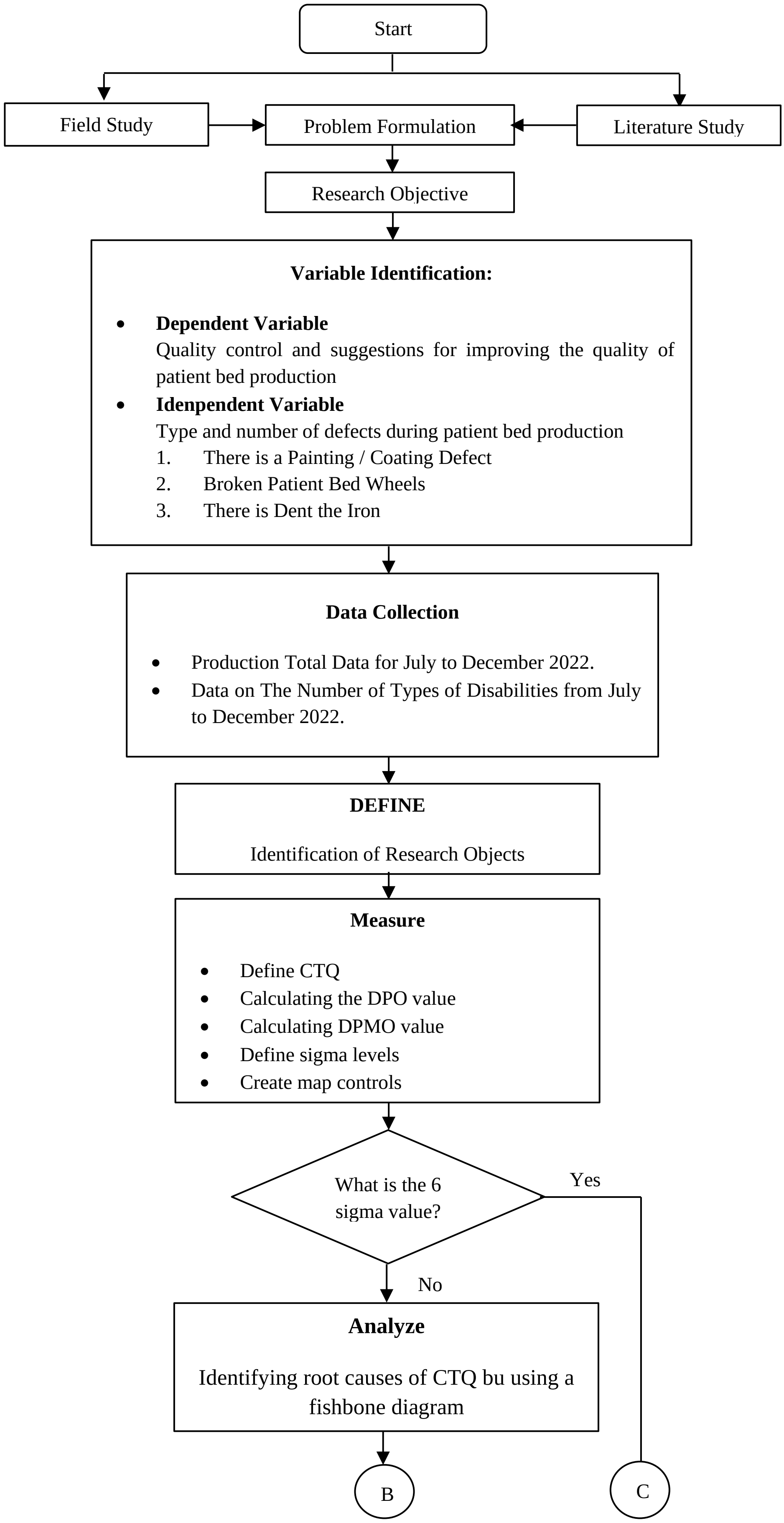
Product quality is a statement of the ability level of a particular brand or product in carrying out the expected functions and as a material to meet basic human needs. To meet consumer needs, companies must carry out strategies in terms of measurement, namely by dividing products, such as grouping food into several categories, for example, taste quality, quantity or portion, menu variations, or variations in the types of food offered. It is undeniable that the distinctive taste, portions that match expectations and tastes, and the many food variants offered will make consumers interested in making repeat purchases and maintaining satisfaction with these products. Product quality is one of the main things that the company pays attention to, quality is an important policy in increasing product competitiveness, the main thing is to provide satisfaction to consumers that exceeds or at least equals product quality from competitors (Santoso, 2019). Many companies were also assisted by the later implementation of Six Sigma with a view to effectively improving production capacities, reducing waste and increasing efficiency. The Six Sigma quality levels have also become good quality control methods and communication tools in the industry (Chen, 2019). Product improvement is a fundamental principle of Six Sigma that involves making the process more efficient in order to produce an optimum product. The six sigma approach is used to identify matters related to error handling and product rework that will cost money, and time, and reduce customer trust. Six Sigma was originally designed to be implemented in the manufacturing industry, but in its development, it was later used for various types of industries (Soemohadiwidjojo, 2017).

Six sigma breakthrough strategies emphasize reducing cycle time and increasing customer satisfaction in determining the level and cost of optimal service quality. Six Sigma's implementation for the service industry is relatively new compared to the application of Six Sigma to the industrial sector (Utomo, 2020). Six Sigma can also be viewed as a customer-focused industrial process control by taking into account the capabilities of the production process. In the application of six sigma, the target for defects or process failures is controlled within the target of 3.4 DPMO (Defects per Million Opportunities or failures per million opportunities) meaning that in 1 million units of product produced, there are only 3.4 defective units. This method is capable of gradually improving quality towards a zero failure rate (zero defect) (Izzah, 2019). Mode Failure Mode and Effects Analysis (FMEA) is a tool for the manufacturing organisation to find their problems and resolve them, in order to improve product quality and reliability. The FMEA shall examine all potential problems objectively and then rate them on the basis of a numerical scale. FMEA is a well known technique, which has been applied to numerous engineering systems for improving reliability, quality and safety of the system. (Aized, 2020). FMEA identifies information on each type of failure, causes of failure, impact of failure, and recommended actions. Furthermore, to find out the priority level that is considered to have a high risk of each failure, the Risk Priority Number (RPN) method is used. The RPN value is derived from the multiplication of the severity of each failure impact, the probability of occurrence of each cause of failure, and the probability of detection of each cause of failure (Situngkir, 2019).

To analyze a specific product or system, a cross-functional team should be established for carrying out FMEA. In FMEA, component failures are linked to risk events, while each failure can become the object of detailed failure analysis and corrective action planning. Due to innovation in implementing and managing projects, effective use of FMEA technique has been proposed (Zuniawan, 2020). The FMEA process will test the process capability which will test the process capability that will be used to make components, sub-systems, and systems (Aprianto, 2021). The purpose of FMEA is to find weak points in the production process and analyze the severity and evaluate the effects in addition to finding solutions and measures to prevent failure (Ikasari, 2021).

3. RESEARCH METHOD

Steps in quality improvement research using Six Sigma and FMEA methods in the process of making Patient Beds at PT. Karya Indah Medika is presented in Figure 1.


Start
Field Study
Problem Formulation
Literature Study
Research Objective
Variable Identification:
Dependent Variable
Quality control and suggestions for improving the quality of patient bed production
Idenpendent Variable
Type and number of defects during patient bed production
1. There is a Painting / Coating Defect
2. Broken Patient Bed Wheels
3. There is Dent the Iron
Data Collection
Production Total Data for July to December 2022.
Data on The Number of Types of Disabilities from July to December 2022.
DEFINE
Identification of Research Objects
Measure
Define CTQ
Calculating the DPO value
Calculating DPMO value
Define sigma levels
Create map controls
What is the 6 sigma value?
Yes
No
Analyze
Identifying root causes of CTQ bu using a fishbone diagram
B
C

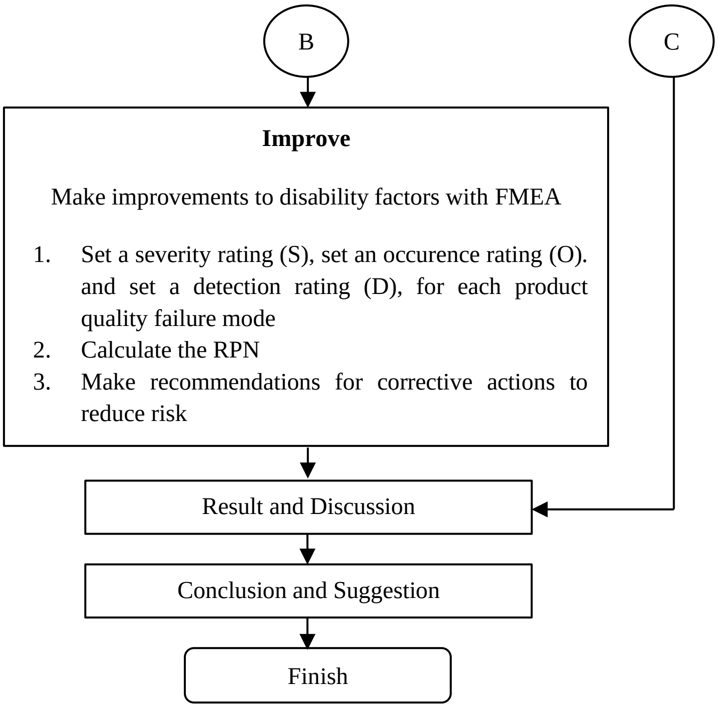


Figure 1. Research stages

Figure 1 is a research stage in the form of steps to research to get the results of the research to be carried out. The sequence of the above steps is to carry out literature studies and field surveys to obtain the formulation of the problem and also the objectives of the research. Followed by the identification of the dependent variable and independent variable. Then the necessary data collection is carried out, namely data on the amount of production and also data on the number of types of defects in production. After that, data processing was carried out using Six Sigma (Define, Measure, Analyze, and Improve) and FMEA (Failure Mode Effect Analysis)

4. RESULT AND DISCUSSION

In the calculation using the six sigma method and improvement recommendations using the FMEA method with the following results.

Table 1. Data on the number of production and patient bed defects

No	Month	Total Production	Total *Defect*	Percentage Defect (%)
1	July	64	7	10.9%
2	August	72	15	20.8%
3	September	63	8	12.7%
4	October	70	10	14.3%
5	November	62	7	11.3%
6	December	61	6	9.8%
	Total	**392**	**53**	**13.5%**

(Source: Production data PT. Karya Indah Medika, 2023)

In Table 1 obtained internal company data regarding the number of defects that occurred during 6 months of patient bed production.

Table 2. Data on types of defects in patient beds

No	Month	Defect Type			Total Defect (Unit)
		Coating Defect	Broken Wheel	Detend Iron	
1	July	2	2	3	7
2	August	6	4	5	15

No	Month	Defect Type			Total Defect (Unit)
		Coating Defect	Broken Wheel	Detend Iron	
3	September	1	5	2	8
4	October	3	4	3	10
5	November	3	3	1	7
6	December	1	2	3	6
	Total	**16**	**20**	**17**	**53**

(Source: Production data PT. Karya Indah Medika, 2023)

In Table 2 obtained internal company data regarding the number of defects that occurred during 6 months in the production of patient beds at PT. Beautiful Medics. The defects found were in the form of coating defects, broken wheels, and dented iron. Based on these data, it can be seen that defects often occur during the production process.

4.1. Define

The Define phase is the first operational step in the Six Sigma quality improvement program. At this stage, the most important thing is the identification of the product and or process to be repaired. The problem that is often faced by this company is the high number of defects that occur in the production process of Patient Beds.

Table 3. Pengolahan data Diagram Pareto

Defect	Total Defect	Percentage Defect (%)	Percentage Defect (%)
Broken Wheel	20	37.74	37.74
Dent Iron	17	32.08	69.81
Coating Defect	16	30.19	100
Total	**53**		

(Source: Processed data, 2023)

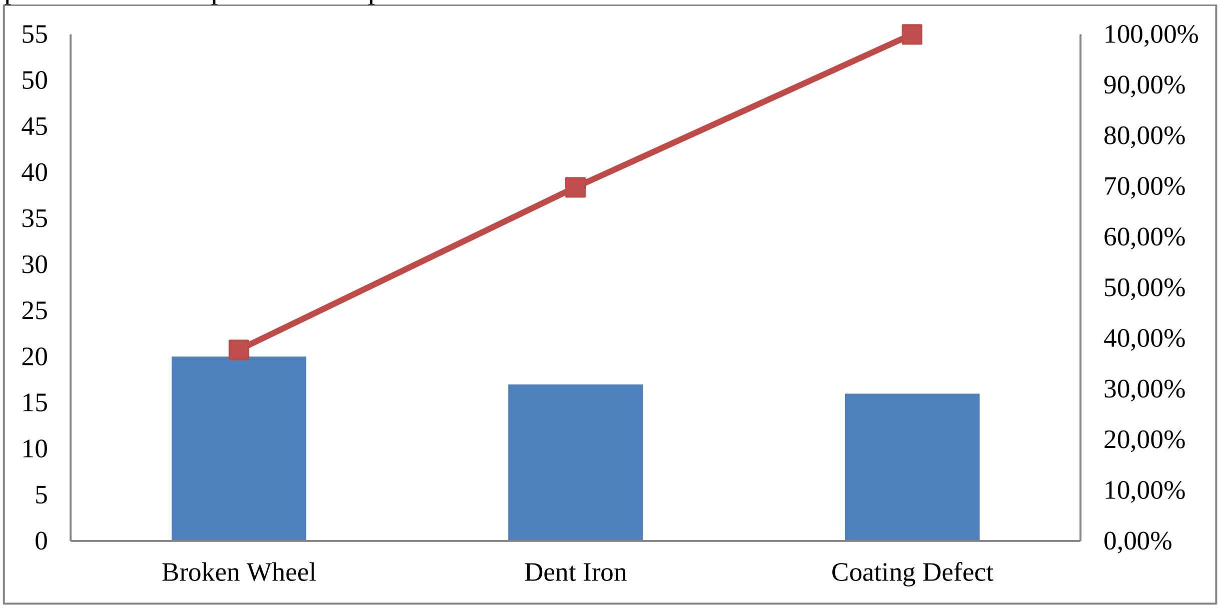


Figure 2. Histogram of the number of patient bed defect types
(Source: Processed Data, 2023)

Based on Table 3 Pareto diagrams can be formed, and the number of defects that occur in patient bed products can be seen in Fig 2. From the Pareto diagram above, it can be seen that the highest number of defects is broken wheel defects of 20 units, with a percentage of 37.74%. Meanwhile, the percentage of dented iron defects was 32.08%, and the percentage of coating defects was 30.19%. It is concluded that the first priority to be addressed concerning all three shortcomings is a broken wheel defect.

4.2. Measure

The second stage in the Six Sigma method is Measure. At this stage what is done is as follows:

4.2.1. Defining Key Quality Characteristics (CTQ)

Determine key quality characteristics, namely any key characteristics that make a product not meet customer expectations. CTQ is a way of measuring products or processes where performance standards or specification limits must be following customer satisfaction. The key quality characteristics of these products consist of 3 CTQs, namely: **(i) There is a coating defect.** There is a painting defect on the iron surface of the patient bed. This coating defect can be run. Runs are paint defects caused by too much paint adhering to the surface.

Figure 3. Coating defect

(ii) Broken patient bed wheels. Several broken wheels that could not support the load, thereby hindering the movement of patient bed products.

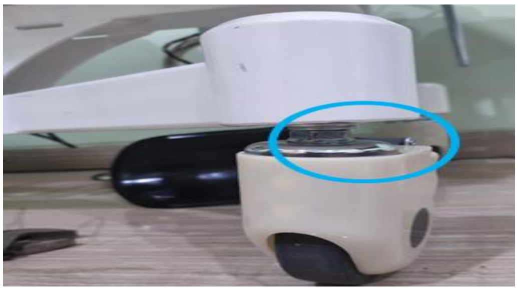


Figure 4. Broken wheel

(iii) There is dent in the iron. There is dented iron during the production process, for example during the assembly process. Thus causing the dented iron plate to not be connected perfectly.

Figure 5. There is a Coating Defect

4.2.2. Calculating DPO Value

To find the DPO (Defect Per Opportunity) value, it can be done through the calculation below:

- July

Based on the data in Table 1 and Table 2, the DPO value can be calculated as follows:

$$DPO = \frac{\text{Total product defects}}{\text{Number of units X CTQ}}$$

$$DPO = \frac{7}{64 \text{ X } 3} = 0{,}036$$

From the calculation above, it can be seen that the probability of a defect occurring in July is 0.04 out of 64 units. The calculations from August to December are attached in the attachment. The following is the result of calculating the DPO (Defect Per Opportunity) value based on the data in Table 1 and Table 2.

Table 4. DPO value of Juli-December 2022

Month	Total Production	Total Defect	CTQ	DPO
July	64	7	3	0.036
August	72	15	3	0.069
September	63	8	3	0.042
October	70	10	3	0.048
November	62	7	3	0.038
December	61	6	3	0.033

(Source: Processed data, 2023)

4.2.3. Calculating DPMO Value

To find the DPMO (Defect Per Million

Opportunity) value, it can be done through the calculation below:

- July

Based on the data in Table.1 and Table.2, it is possible to calculate the DPMO value as follows:

$$DPMO = \frac{\text{Total product defects}}{\text{Number of units X CTQ}} \text{ x } 1.000.000$$

$$DPMO = \frac{7}{64 \text{ X } 3} \text{ x } 1.000.000 = 36458$$

From the calculation above, it can be seen that in July an inspection was carried out on 64 units and there were 7 defects. And the probability of a defect occurring per one million events was 36,458. The calculations from August to December are attached in the attachment. The following is the result of calculating the DPMO (Defect Per Million Opportunity) value based on the data in Table1 and Table 2.

Table 5. DPMO value of Juli-December 2022

Month	Total Production	Total *Defect*	CTQ	DPO	DPMO
July	64	7	3	0.036	36458
August	72	15	3	0.069	69444
September	63	8	3	0.042	42328
October	70	10	3	0.048	47619
November	62	7	3	0.038	37634
December	61	6	3	0.033	32787
Average				**0.044**	**44379**

(Source: Processed data, 2023)

4.2.4. Determining Sigma Levels

Based on the data in Table 5. it is possible to calculate the sigma level value by converting the DPMO value with the help of the sigma table, then interpolating it. The calculation is as follows:

Table 6. Sigma level recapitulation

Month	Total Production	Total Defect	CTQ	DPO	DPMO	Level Sigma
July	64	7	3	0.036	36458	3.29
August	72	15	3	0.069	69444	2.98
September	63	8	3	0.042	42328	3.22
October	70	10	3	0.048	47619	3.17
November	62	7	3	0.038	37634	3.28
December	61	6	3	0.33	32787	3.34
Average						**3.21**

(Source: Processed data, 2023)

The average sigma level from July to December 2022 is 3.21, which means that it still has not met the target, namely towards a world-class company standard or 6σ. Therefore, to achieve 6σ, improvements are made by analyzing the factors that cause defects.

4.2.5. Create a Control Map

To make a control map, it can be done through the calculations below. Based on the data in Table 1. and Table 2. it is possible to calculate the proportion values, 3σ, UCL, and LCL from July – December 2022. The calculations are as follows (example of product calculations for July 2022):

- Calculating Proportions (P)

$$P = \frac{\text{Defective product}}{\text{Inspected product}}$$

$$P = \frac{7}{64} = 0,109$$

- Calculating 3σ

$$3\sigma = \frac{3\sqrt{p\ (1-p)}}{\sqrt{n}}$$

$$3\sigma = \frac{3\sqrt{0,109\ (1-0,109)}}{\sqrt{64}} = 0,117$$

- Calculating UCL (Upper Control Limit)

UCL = p + 3σ
UCL = 0,109 + 0,117 = 0,226

- Calculating LCL (Lower Control Limit)

UCL = p - 3σ
UCL = 0,109 - 0,117 = - 0,008

From the calculation above it can be seen that the proportion value in July is 0.109, the 3σ value in July is 0.117, and the UCL and LCL values in July are respectively 0.226 and -0.008. The calculations from August to December are attached in the attachment. The following is the manufacture of control maps in Fig.6 and Table 7. Calculation of the proportion, 3σ, UCL, and LCL values of the product.

Table 7. Calculation of Proportion Value, 3σ, UCL, dan LCL

Month	Quantity of		Proportion	$3\sigma = \frac{3\sqrt{p\,(1-p)}}{\sqrt{n}}$	UCL = p + 3σ	LCL = p - 3σ
	Inspection (n)	Defect				
July	64	7	0.109	0.117	0.226	-0.008
Agustus	72	15	0.208	0.144	0.352	0.065
September	63	8	0.127	0.126	0.253	0.001
Oktober	70	10	0.143	0.125	0.268	0.017
November	62	7	0.113	0.121	0.233	-0.008
December	61	6	0.098	0.114	0.213	-0.016
Total	392	53	0.799	0.747	1.546	0.052
Average	**65.33**	**8.83**	**0.133**	**0.124**	**0.58**	**0.009**

(Source: Processed data, 2023)

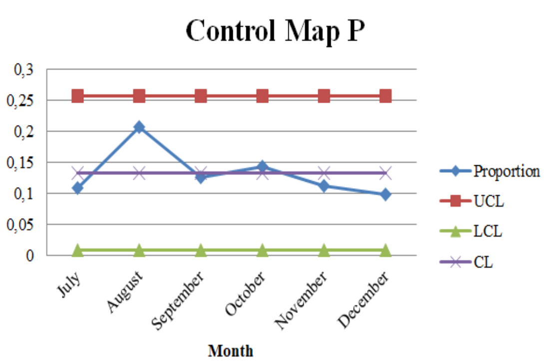


Figure 6. Control Map P
(Source: Processed Data, 2023)

Control Map Analysis

Product control map analysis has an average UCL value of 0.258, an LCL value of 0.009, and a proportion value of 0.133. From the control map above, there are no more points that are outside the control limits, this indicates that the process is under control, but follow-up is needed to improve quality towards the target of world-class companies that have a very small failure rate to zero (zero defects).

4.3. Analyze

The analysis phase is the next step in which an analysis of the results of the measurements carried out in the previous stage is carried out and the root cause of the CTQ is determined using a cause and effect diagram (fishbone diagram).

a. Fishbone Diagram for Coating Defect

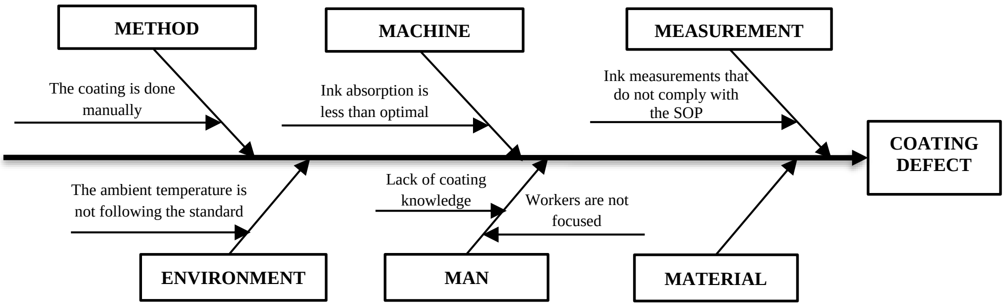


Figure 7. Fishbone diagram for coating defect

b. Fishbone Diagram for Broken Wheel Defect

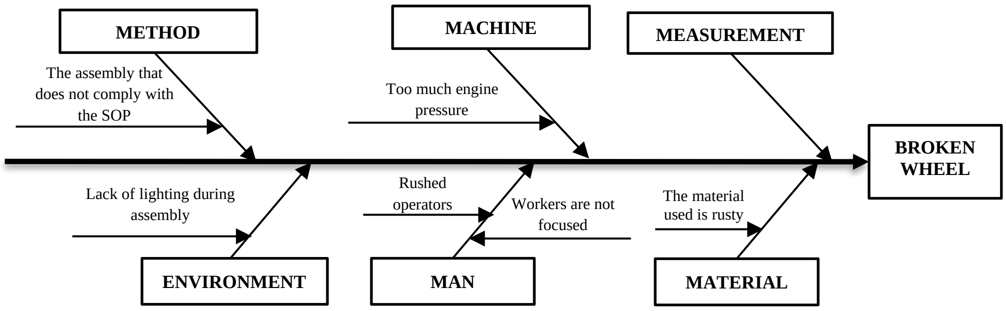


Figure 8. Fishbone diagram for broken wheel defect

c. Fishbone Diagram for Dent Iron

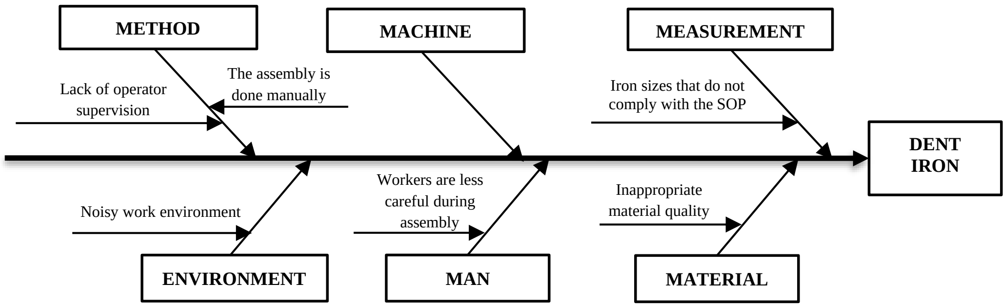


Figure 9. Fishbone diagram for dent iron

4.4. Improve

In the improvement stage, several ideas will be proposed to improve the various defects that have occurred. At the improvement stage, the defect factor will be repaired using the FMEA (Failure Mode Effect Analysis) method.

- **FMEA Coating Defect**

Table 8. FMEA coating defect

Modes of Failure	*Effect of Failure*	S	*Cause of Failure*	O	*Current Controls*	D	RPN
Cacat Coating	There is peeling paint and paint clumps	5	Methods: The coating is done manually	2	Coating using supporting equipment	4	40
			Machine: Ink absorption is less than optimal	6	Controlling and supervising ink absorption	6	180
			Measurement: Ink measurements that do not comply with the SOP	5	Double-check when doing ink measurements	4	100
			Environment: Non-standard ambient temperature	6	Check the temperature during the coating process	5	150
			Man: Lack of coating knowledge	2	Conducted training on coatings	4	40
			Workers are not focused	1	There is a shift change	5	25

FMEA analysis for the types of coating defects is shown in Table 8. Based on the standard severity (S), occurrence (O), and detection (D) values in table 2.3 to table 2.5 for coating defects with the production of peeling paint and clumping paint getting an S value of 5, meaning it has a moderate effect and can still be operated properly even though it reduces the level of product performance. For the cause of failure, coating done manually gets an O value of 2, with current controls coating using supporting equipment gets a D value of 4, while the Risk Priority Number (RPN) value is obtained from S x O x D or 5 x 2 x 4 so the result is 40. For causes of failure ink absorption is not optimal, it gets an O value of 6, with current controls controlling ink absorption, it gets a D value of 6, so the RPN value is 180. For causes of failure, ink measurement that does not comply with SOP gets an O value of 5, with current controls, an SOP for the dosage of coating ink gets a D value of 4, so the RPN value is 100. For the cause of failure, the ambient temperature that is not according to the standard gets an O value of 6, with current controls checking the temperature during the coating process, it gets a D value of 5, so the RPN value is 150. For the cause of failure, lack of knowledge about the coating process gets an O value of 2, with current controls, training on coating gets a D value of 4, so the RPN value is 40. And for the cause of less focused failure workers get an O value of 1, with current controls there is a shift change getting a D value of 5, so the RPN value is 25.

The recommendations for improvement are listed in Table 9. Sorted by priority number from the largest to the smallest RPN value, for coating ink absorption that is less than optimal, it gets an RPN value of 180 with recommendations for improvements to control and supervise the absorption of coating ink. For environmental temperature conditions that do not meet the standard, an RPN value of 150 is obtained with recommendations for improvement by checking the temperature during the coating process and adjusting the room temperature. For ink measurement conditions that do not comply with the SOP, an RPN value of 100 is obtained with recommendations for improvement to re-check when measuring ink. For manual coating conditions, an RPN value of 40 is obtained with recommendations for improving coating implementation using appropriate coating equipment. For conditions of lack of knowledge about coatings, an RPN value of 40 is obtained with recommendations for improvement by conducting training on coatings and also monitoring coating ink doses. And for the condition of less focused workers, they get an RPN value of 25 with recommendations for improving shift changes to prevent worker fatigue which causes workers to be unfocused.

Table 9. Coating defect repair recommendations

Priority Number	Cause of Failure	RPN	Recommendation
1	Ink absorption is less than optimal	180	Controlling and supervising ink absorption
2	Non-standard ambient temperature	150	1. Check the temperature during the coating process 2. Set room temperature
3	Ink measurements that do not comply with the SOP	100	Double-check when doing ink measurements
4	The coating is done manually	40	Coating using supporting equipment
5	Lack of coating knowledge	40	Conducted training on coatings
6	Workers are not focused	25	There is a shift change

- FMEA Broken Wheel

Table 10. FMEA broken wheel

Modes of Failure	Effect of Failure	S	Cause of Failure	O	Current Controls	D	RPN
Broken Wheel	The patient bed cannot operate properly and cannot be pushed	8	**Method** The assembly that does not comply with the SOP	3	Supervise during assembly	5	120
			Machine Too much engine pressure	7	Check machine settings	4	224

Modes of Failure	Effect of Failure	S	Cause of Failure	O	Current Controls	D	RPN
			Environment Lack of lighting at the time of assembly	2	Checking the work environment according to SOP criteria	7	112
			Man Rushed operators	6	Operators are more thorough and not in a hurry	6	288
			Workers are not focused	4	There is a shift change	5	160
			Material The material used is rusty	7	Checking raw materials before use	5	280

FMEA analysis for the types of coating defects is shown in Table 10. Based on the standard severity (S), occurrence (O), and detection (D) values in Table 2.3 to Table 2.5 for broken wheel defects with the result that the production of patient beds cannot operate properly and cannot be pushed, it gets an S value of 8, meaning it gives a high bad influence so that it cannot be accepted by customers. For cause of failure the assembly that is not following the SOP gets an O value of 3, with current controls supervising when the assembly is in progress gets a D value of 5, while the Risk Priority Number (RPN) value is obtained from S x O x D or 8 x 3 x 5 so the result is 120. For causes of failure engine pressure that is too strong gets an O value of 7, with current controls made by SOP checking the engine settings gets a D value of 4, so the RPN value is 224. For causes of failure lack of lighting when assembly gets the O value is 2, with current controls checking the work environment according to the SOP criteria, the D value is 7, so the RPN value is 112. For causes of failure, operators who are in a hurry get an O value of 6, with current controls, operators who are more thorough and not in a hurry get a D value of 6, so the RPN value is 288. For causes of failure, workers who are not focused get an O value of 4, with current controls there is a shift change, they get a D value of 5, so the RPN value is 160. And for the cause of failure, the material used is already arrayed and gets an O value of 7, with current controls checking raw materials before use getting a D value of 5, so the RPN value is 280.

The recommendations for improvement are listed in Table 11. sorted by priority number from the largest to the smallest RPN value, for operators who are in a hurry to get an RPN value of 288 with recommendations for improving operators to be more thorough and not in a hurry in doing work. For materials used that are rusty, they get an RPN value of 280 with recommendations for improvement by checking raw materials before use. For engine pressure that is too strong, it gets an RPN value of 224 with recommendations for improvement by checking the engine settings. For the condition of less focused workers, they get an RPN value of 160 with recommendations for improvements to change shifts to prevent worker fatigue which causes workers to be unfocused. For assembly conditions that do not comply with the SOP, an RPN score of 120 is obtained with recommendations for improvement by conducting supervision during the assembly. And for the lack of lighting conditions during the assembly, it received an RPN value of 112 with recommendations for improving the work environment checking so that it complies with the SOP criteria.

Table 11. Broken wheel defect repair recommendations

Priority Number	Cause of Failure	RPN	Recommendation
1	Rushed operators	288	Operators are more thorough and not in a hurry
2	The material used is rusty	280	Checking raw materials before use
3	Too much engine pressure	224	Check machine settings

Priority Number	Cause of Failure	RPN	Recommendation
4	Workers are not focused	160	There is a shift change
5	The assembly that does not comply with the SOP	120	Supervise during assembly
6	Lack of lighting at the time of assembly	112	Checking the work environment according to SOP criteria

- FMEA Dent Iron

Table 12. FMEA dent iron

Modes of Failure	Effect of Failure	S	Cause of Failure	O	Current Controls	D	RPN
Dent Iron	The dented iron plate could not be connected perfectly	8	**Method** Lack of operator supervision	8	Regular monitoring of operators is carried out	4	256
			Assembly is done manually	6	Assembly can be done with supporting equipment	3	144
			Measurement Iron sizes that do not comply with the SOP	7	Double-check the size of the iron used	5	280
			Environment Noisy work environment	8	Work environment disipline	3	192
			Man Workers who are less careful during assembly	7	Workers have to be more careful	5	280
			Material Inappropriate material quality	7	Checking the quality of raw materials before processing	7	392

FMEA analysis for the types of dented iron defects is shown in Table 12. Based on the standard severity (S), occurrence (O), and detection (D) values in table 2.3 to table 2.5 for dented iron defects with the production of dented iron plates which cannot be perfectly linked gets an S value of 8, meaning it gives a high bad effect so that it cannot be accepted by customers. For the cause of failure, lack of operator supervision gets an O value of 8, with current controls carrying out routine operator supervision getting a D value of 4, while the Risk Priority Number (RPN) value is obtained from S x O x D or 8 x 8 x 4 so the result is 256. For causes of failure assembly done manually gets an O value of 6, with current controls assembly can be carried out with supporting equipment gets a D value of 3, so the RPN value is 144. For causes of failure, the size of iron that is not following the SOP gets the O value is 7, with current controls assembly can be carried out with supporting equipment to get a D value of 5, so the RPN value is 280. For causes of failure, the environment is not conducive to getting an O value of 8, with current controls orderliness of the work environment gets a D value of 3, so the RPN value is 192. For the cause of failure workers are not careful during the assembly process gets an O value of 7, with current controls workers must be more careful, and also supervised workers get a D value of 5, so the RPN value is 280 And the cause of failure of inappropriate material quality gets an O value of 7, with current controls checking the quality of raw materials before processing gets a D value of 7, so the RPN value is 392.

The recommendations for improvement are listed in Table 13. sorted by priority number from the largest to the smallest RPN value, for the quality of materials that are not suitable, an RPN value of 392 is obtained with recommendations for improving raw material quality checking before processing. For the condition of workers who were not careful during the assembly, they received an RPN value of 280 with recommendations for improvement, workers had to be more careful and supervise workers. For iron sizes that are not following the SOP, an RPN value of 280 is obtained with recommendations for improvement by re-checking the size of iron used. For conditions of lack of operator supervision, an RPN value of 256 is obtained with recommendations for improvements to carry out routine operator supervision. For non-conducive environmental conditions, an RPN score of 192 is obtained with recommendations for improving the orderliness of workers in the work environment. And for the condition that the assembly is done manually, it gets an RPN value of 144 with recommendations for assembly repairs to be carried out with supporting equipment.

Table 13. Dent iron defect repair recommendations

Priority Number	Cause of Failure	RPN	Recommendation
1	Inappropriate material quality	392	Checking the quality of raw materials before processing
2	Workers who are less careful during assembly	280	1. Workers have to be more careful 2. Supervision of workers is carried out
3	Iron sizes that do not comply with the SOP	280	Double-check the size of the iron used
4	Lack of operator supervision	256	Regular monitoring of operators is carried out
5	Noisy work environment	192	Work environment disipline
6	Assembly is done manually	144	Assembly can be done with supporting equipment

Based on the results of processing patient bed product data in July - December 2022 in Table 5, based on the calculation results from the table it is known that the July production obtained a sigma value of 3.29; production in August received a sigma value of 2.98; production in September received a sigma value of 3.22; production in October received a sigma value of 3.17; production in November received a sigma value of 3.28; and production in December received a sigma value of 3.34; so that the average sigma level is 3.21, which means that it still has not met the target, namely towards world-class company standards or 6σ. Therefore, to achieve 6σ, improvements are made by analyzing the factors that cause defects.

Therefore, the factors that cause defects are listed in Table 8 and Table 9. Factors that cause coating defects include ink absorption that is less than optimal, ambient temperature that is not up to standard, ink measurements that are not following SOP, manual coating, lack of knowledge about the coating process, and less focused workers. Proposed improvements include controlling and monitoring ink absorption, checking temperature during the coating process, adjusting room temperature, re-checking when measuring ink, coating using supporting equipment, conducting training on coatings, and changing shifts.

In Table 10 and Table 11, the factors that cause broken wheel defects include operators who are in a hurry, the materials used are kart, machine pressure being too strong, workers not focused, assembly not following SOP, and lack of lighting during assembly. As for the proposed improvements, namely the operator is more thorough and not in a hurry, checks raw materials before use, checks machine settings, has shift shifts, supervises assembly during assembly, and checks the work environment according to SOP criteria.

In table 12. and Table 13. factors causing dented iron defects include inappropriate material quality, workers who are not careful during assembly, iron sizes that are not following SOP, lack of operator supervision, a non-conducive environment, and assembly being done manually. As for the proposed improvements, namely checking the quality of raw materials before processing, workers must be more careful, carry out routine supervision of workers and operators, re-check the size of the iron used, implement an orderly work environment, and assembly can be carried out with supporting equipment.

4.5. Control

Control or control stage, namely controlling and supervising the improvement plan recommended or proposed to be realized in the company. This control is entirely the authority of the company to realize the improvement plan. Here are some recommended repair plans to prevent the same problem from coming back: (1) Carry out special machine maintenance, to reduce the causes of errors that can cause product defects to be produced. (2) Provide training on the use of machines to all workers to improve the quality of the company's human resources. (3) It is necessary to prioritize and evaluate employee performance to achieve effectiveness and efficiency in the patient bed production process.

5. CONCLUSION

Based on the results of data processing from July to December 2022, the most dominant defect was found in patient bed products, namely broken wheels with a defect of 13.5% of the total production, then for dented iron defects a defect of 4.3% was found, and in coating defects a defect of 4.1% was obtained from the total of all production. Based on the data obtained from July to December 2022, a total production of 392 units was obtained and the total number of defects that occurred was 53 units, resulting in a defect percentage of 13.5% with a sigma value of 3.19σ. Based on the results of RPN calculations for FMEA of patient bed products, several risks have the highest priority level to make improvements to minimize the possibility of errors. The calculation of the highest RPN value is 392 from the type of dented iron defect with the cause of the defect, namely the quality of the material that is not up to standard. Recommendations for improvement for this problem are checking the quality of raw materials before processing.

REFERENCES

Aized, T., Ahmad, M., Jamal, M.H., Mahmood, A., Rehman, S.U.U., & Srai, J.S. (2020). Automotive Leaf Spring Design and Manufacturing Process Improvement Using Failure Mode and Effects Analysis (FMEA). *International Journal of Engineering Business Management*. 12: 1-13. https://doi.org/10.1177/1847979020942438.

Angin, D.P., Wiyatno, T.N., Pratiwi, N.P., Damayanti, Y., & Renggani, R.R. (2023). *Manajemen Mutu*. Klaten: Lakeisha.

Aprianto, T., Setiawan, I., & Purba, H.H. (2021). Implementasi Metode *Failure Mode and Effect Analysis* pada Industri di Asia - Kajian Literatur. *Jurnal Manajemen & Teknik Industri*. 11(2): 165-174. http://dx.doi.org/10.30587/matrik.v21i2.2084.

Chen, K.S., Wang, C.H., Tan, K.H., & Chiu, S.F. (2019). Developing One-Sided Specification Six-Sigma Fuzzy Quality Index And Testing Model To Measure The Process Performance Of Fuzzy Information. *International Journal of Production Economics*. 208: 560-565. https://doi.org/10.1016/j.ijpe.2018.12.025

Dahniar, T. (2022). *Pengendalian Mutu Produk pada Industri Komponen Sepeda Motor Menuju Zero Defect untuk Mencapai Optimalisi Manufaktur*. Tangerang: Pascal Books.

Firmansyah, R., & Yuliarty, P. Implementasi Metode DMAIC pada Pengendlaian Kualitas *Sole Pkate* di PT Kencna Gemilang. *Jurnal Penelitian dan Apliasi Sistem & Teknik Industri*. 14(2): 167-180. http://dx.doi.org/10.22441/pasti.2020.v14i2.007

Fitriana, R., Sari, D.K., & Habyba, A.N. (2021). *Pengendalian dan Penjaminan Mutu*. Banymas: Wawasan Ilmu.

Harsanto, B. 2022. *Dasar - Dasar Manajemen Operasi Edisi Kedua*. Jakarta: Kencana.

Herlambang, H. (2020). Six Sigma Implementation in Connector and Terminals Manufacturing Company : A Case Study. *Indonesian Journal of Industrial Engineering & Management*. 1(1): 1-11. http://dx.doi.org/10.22441/ijiem.v1i1

Ikasari, D.M., Santoso, I., Astuti, R., Septifani, R., & Armanda, T.W. (2021). *Manajemen*

Risiko Agroindustri : Teori dan Aplikasinya. Malang: UB Press.

Izzah, N., Rozi, M.F. (2019). Analisis Pengendalian Kualitas dengan Metode Six Sigma-DMAIC dalam Upaya Menguragi Kecacatan Produk Rebana pada UKM Alfiya Rebana Gresik. *Jurnal Ilmiah: Soulmath*. 7(1): 13-25. http://dx.doi.org/10.25139/smj.v7i1.1234

Lidan, A., Syahputra, A., Robby, A.D., Hidayat, M., Al-Adawiyah, R., Nur, R., Ma'ruf, R., & Nasution, S. (2023). *Manajemen Mutu Terpadu dalam Pendidikan*. Medan: Umsu Press.

Santoso, J.B. (2019). Pengaruh Kualitas Produk, Kualitas Pelayanan, dan Harga Terhadap Kepuasan dan Loyalitas Konsumen (Studi pada Konsumen Geprek Bensu Rawamangun). *Jurnal Akuntansi dan Manajemen*. 16(1): 127-146. https://doi.org/10.36406/jam.v16i01.271

Soemohadiwidjojo, A.T. (2017). *Six Sigma : Metode Pengukuran Kinerja Perusahaan Berbasis Statistik*. Jakarta : Raih Asa Sukses.

Situngkir, D.I., Gultom, G., & Tambunan, D.R.S. (2019). Pengaplikasian FMEA untuk Mendukung Pemilihan Strategi Pmeeliharaan pada Paper Machine. *Jurnal Teknik Mesin Untirta*. 5(2): 39-43. http://dx.doi.org/10.36055/fwl.v1i1.5489

Taufik. (2022). *Pengendalian Kualitas Produk Perlengkapan Kamar Mandi (Sanitary Asessories) menggunakan Metode DMAIC*. Tangerang : Pascal Books.

Utomo. (2020). A Systematic Literature Review of Six Sigma Implementation in Services Industries. *Indonesian Journal of Industrial Engineering & Management*. 1(1): 45-57. http://dx.doi.org/10.22441/ijiem.v1i1

Zuniawan, A. (2020). A systematic Literature Review of Failure Mode and Effect Analysis (FMEA) Implementation in Industries. *Indonesian Journal of Industrial Engineering & Management*. 1(2): 59-68. http://dx.doi.org/10.22441/ijiem.v1i2