QUALITY CONTROL ANALYSIS, SIX SIGMA, DMAIC, AND ROOT CAUSE ANALYSIS OF RING CVT (CASE STUDY AT PT. DENAPELLA LESTARI)

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Abstract

PT. Denapella Lestari is a company engaged in metal stamping, machining parts, and the engineering industry. This company products car and motorcycle parts. PT. Denapella Lestari itself continuously checks the products produced, one of the products of PT. Denapella Lestari is a Ring CVT. However, the production process cannot be separated from errors that cause defective products and do not meet general standards to be sent to customers. Therefore, quality control analysis is needed to maintain the quality produced using the DMAIC and Root Cause Analysis method consisting of five stages: define, measure, analyze, improve, and control. One of the problems that exist in the company is the number of defective Ring CVT products, especially in 2020, as many as 2262 pieces with 14 types of defect and are the value of 4.50 sigma.

Keywords
Quality control, DMAIC, Root Cause Analysis.

1. Introduction
The industrial world cannot be separated from the quality or quality of goods which are the main factors for consumers in deciding to consume products or services. Quality is the overall characteristics and characteristics of service products that support the ability to satisfy needs. The definition emphasizes customer focus (Kotler P & K L Keller 2016). According to Irwan and Haryiono (2015), this principle in statistical analysis fulfils quality requirements by the standards desired by customers. Therefore, the company always tries to maintain the quality of its products to produce good products to maintain customer satisfaction. Quality control determines the quality of a product and attempts to maintain an already high quality and reduce the number of damaged materials. The company's quality control can also reduce losses resulting from product damage. Product quality must be maintained throughout the production process until the end of production. In this study, quality control analysis was carried out at PT. Denapella Lestari. PT. Denapella Lestari itself is a company engaged in the metal stamping, machining parts, and engineering industry that has been established since 1995. PT. Denapella Lestari has produced 270 products and has had 30 business partners for 26 years. Products that are produced are not free from manufacturing defects but PT. Denapella Lestari has a fairly good quality control system as their motto "accuracy will determine the quality of products."

2. Literature Review
The literature reviews that are used in this research are:

2.1 DMAIC
DMAIC is an abbreviation of the five improvement steps it comprises: Define, Measure, Analyze, Improve and Control. All of the DMAIC process steps are required and always proceed in the given order.

2.2 SIPOC Diagram

SIPOC (Supplier-Input-Process-Output-Customer) diagrams that can be useful in process improvement efforts. (Gaspersz, 2002).

2.3 Fishbone Diagram

Fishbone diagrams are used when we want to identify possible causes of problems and especially when a team tends to fall into thinking routines (Tague, 2005).

3. Methods

The stages of implementation carried out during practical work are described in the implementation methodology, which can be seen in Figure 1.

Figure 1. Flowchart

4. Data Collection

The following are the types and data of reject goods during 2020 in the CVT Ring production at PT. Denapella Lestari. A Table can be seen in Table 1.

Table 1. Data Of Rejects

REJECT	2020	DATA NG BERDASARKAN JENIS												
Part Name	JENIS NG	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
Ring CVT	Draw Pecah	5	11	6	0	0	0	0	0	0	0	0	0	22
Ring CVT	Draw Keriput	0	26	0	0	0	0	0	5	3	0	0	0	34
Ring CVT	Dakon	168	162	126	50	0	0	175	141	123	78	117	0	1140
Ring CVT	Sobek pinggir	0	0	0	0	0	0	0	0	0	0	0	0	0
Ring CVT	Nabrak / penyok	0	12	11	4	0	0	0	20	13	15	15	0	90
Ring CVT	Burry trimming	0	0	0	0	0	0	0	0	0	0	4	0	4
Ring CVT	Baret / scratch	0	5	0	0	0	0	0	0	0	0	18	0	23
Ring CVT	Cutting minus	67	165	126	32	0	0	41	30	61	101	40	14	677
Ring CVT	Burry cutting	0	0	0	0	0	0	0	0	0	0	0	3	3
Ring CVT	Trial	0	5	0	6	0	0	0	0	0	0	0	0	11
Ring CVT	NG Proses	0	0	83	30	0	0	21	24	8	5	4	22	197
Ring CVT	Chamfer besar	5	0	0	0	0	0	0	0	0	0	6	0	11
Ring CVT	Berkarat	0	0	7	0	0	0	0	0	0	0	0	0	7
Ring CVT	Jump proses	0	0	0	0	0	0	0	0	0	0	0	0	0
Ring CVT	NG Material	0	0	0	0	0	0	8	0	4	16	15	0	43
TOTAL DEFECT		245	386	359	122	0	0	245	220	212	215	219	39	2262
TOTAL PRODUKSI		141897	275991	385269	75279	0	0	152751	155229	182321	202362	82604	15643	1669346

From the data in the Table for the past year, the largest type of defect is Dakon with 168 units in January 2020, 162 units in February, 126 units in March, 50 units in April, 175 units in July, 141 units in August, 123 units in September, 78 units in October and 117 units in November. There are a total of 1140 defect units in 2020. Next, the proportion of defects is calculated to see if the resulting defects are still within the control limits. Data on the proportion of defects in Ring CVT products can be seen in Table 2, and the P chart can be seen in Figure 2.

Table 2. Data On The Proportion of Defects

Month	Total Production	Total Defect	Proportion of Defect	CL	UCL	LCL
January	141897	245	0.001727	0.001355	0.001648	0.001062
February	275991	386	0.001399	0.001355	0.001565	0.001145
March	385269	359	0.000932	0.001355	0.001533	0.001177
April	75279	122	0.001621	0.001355	0.001757	0.000953
July	152751	245	0.001604	0.001355	0.001637	0.001073
August	155229	220	0.001417	0.001355	0.001635	0.001075
September	182321	212	0.001163	0.001355	0.001613	0.001097
October	202362	215	0.001062	0.001355	0.001600	0.001110
November	82604	219	0.002651	0.001355	0.001739	0.000971
Desember	15643	39	0.002493	0.001355	0.002237	0.000473
Total	1669346	2262				

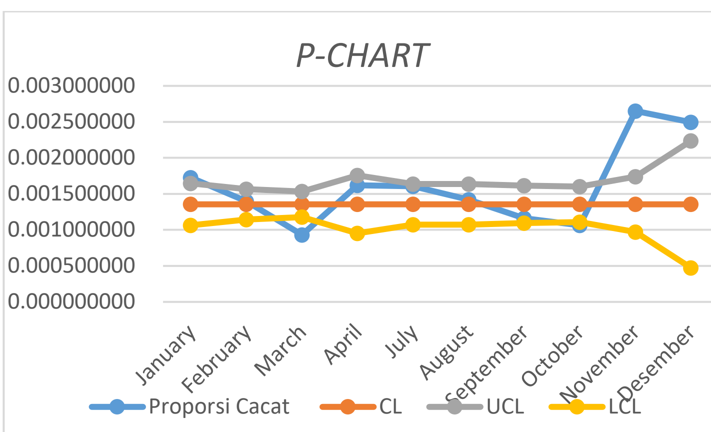

Figure 2. P-Chart

Furthermore, the types of defects that occur in Ring CVT production are sorted from the most frequent to the rare and entered into the cumulative percentage Table. After that, based on the existing data, a Pareto diagram is made. The Table of cumulative percentage can be seen in Table 3 and Pareto Diagram in Figure 3.

Table 3. Cumulative Percentage

No	Type of Defects	Total	Percentage (%)	Cummulative Percentage (%)
1.	Dakon	1140	50.40	50.40
2.	Cutting Minus	677	29.93	80.33
3.	NG Process	197	8.71	89.04
4.	Dent	90	3.98	93.02
5.	NG Material	43	1.90	94.92
6.	Wrinkled Draw	34	1.50	96.42
7.	Scratches	23	1.02	97.44
8.	Broken Draw	22	0.97	98.41
9.	Trial	11	0.49	98.9
10.	Big Chamfer	11	0.49	99.39
11.	Rusty	7	0.31	99.7
12.	Burry Trimming	4	0.18	99.88
13.	Burry Cutting	3	0.13	100
14.	Torn	0	-	
15.	*Jump Proses*	0	-	

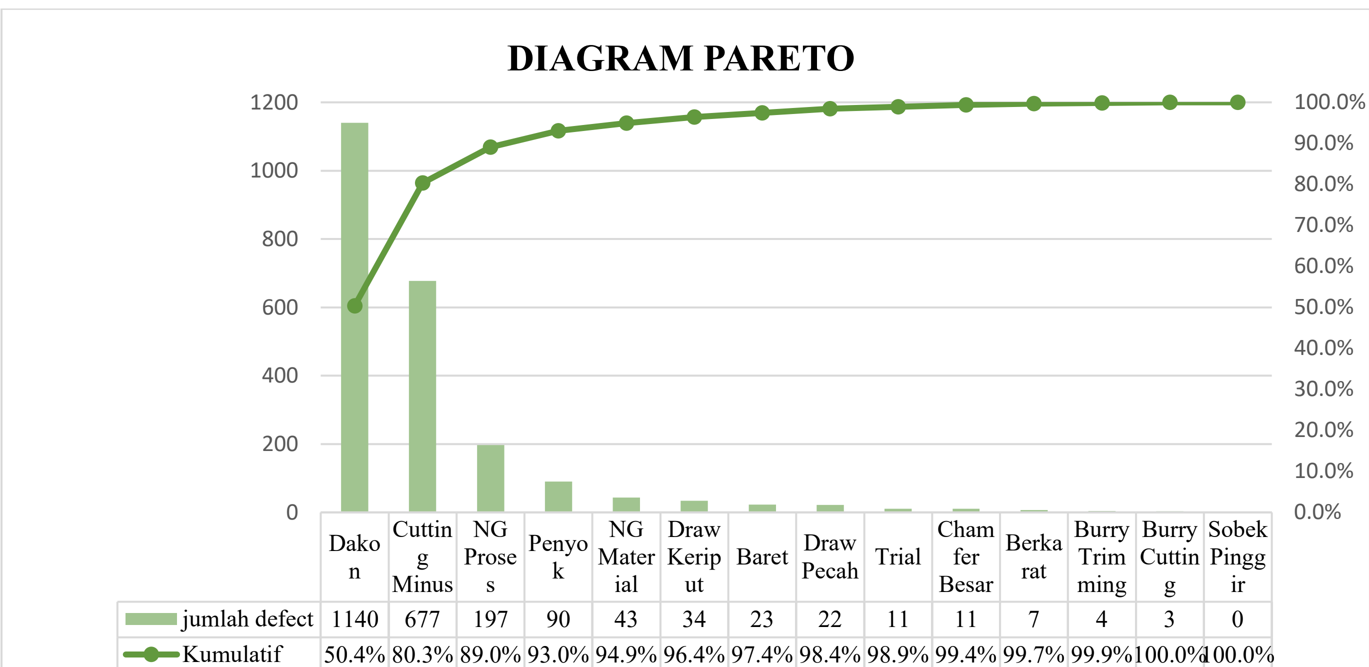

Figure 3. Pareto Diagram

Based on the Pareto diagram and following the 80/20 Pareto rule, the dominant defects are dakon and cutting minus. Both defects are a priority for improvement.

5. Result and Discussion

5.1 Define

The define stage is the first operational step in the six sigma quality improvement program. It is necessary to make a SIPOC (Supplier-Input-Process-Output-Customer) diagram that can be useful in improving processes. (Gaspersz, 2002). The SIPOC diagram of Ring CVT production can be seen in Figure 4.

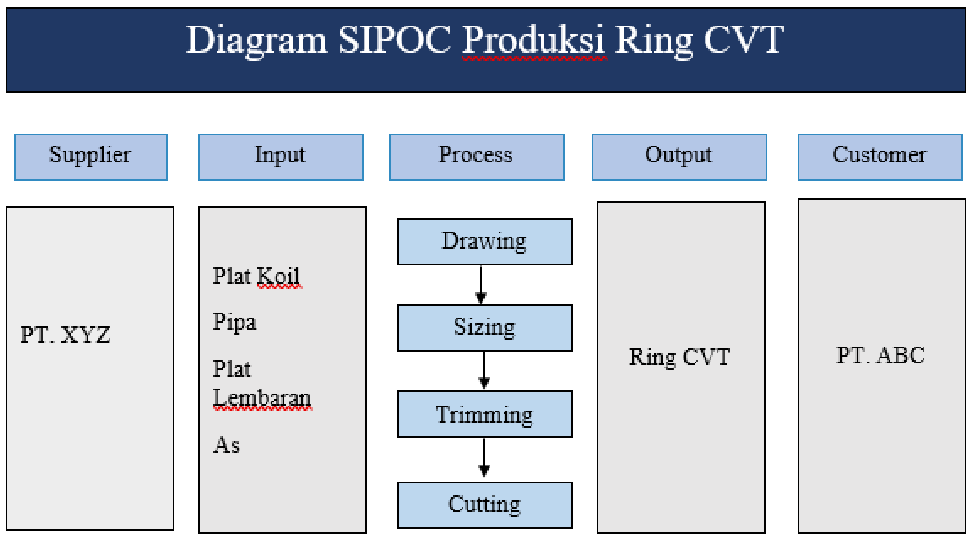

Figure 4. SIPOC Diagram

5.2 Measure

Measurement of the product defect variable contained in the CVT Ring at PT. Denapella Lestari was carried out using the DPMO (Defect Per Million Opportunities) calculation. The results of the DPMO calculation on the CVT ring can be seen in Table 4.

Table 4. Result of the DPMO

Variabel	Januari – Desember 2020
Unit (U)	1669346
Opportunities (OP)	1
Defect (D)	2262
Defect per Unit (DPU)	0.0013550217
Total Opportunities (TOP)	1669346
Defect per Opportunities (DPO)	0.0013550217
DPMO	1,355.0217
Sigma Level	4,50σ

5.3 Analyze

At this stage, an analysis is carried out by finding out the causes of defects in CVT Ring products with the help of fishbone diagrams or fishbone diagrams against two types of defects that cause defects in CVT Ring products. The data on this fishbone diagram was obtained by conducting interviews with leaders and quality control operators in the production of Ring CVT. The Fishbone diagram can be seen in Figure 5 and Figure 6.

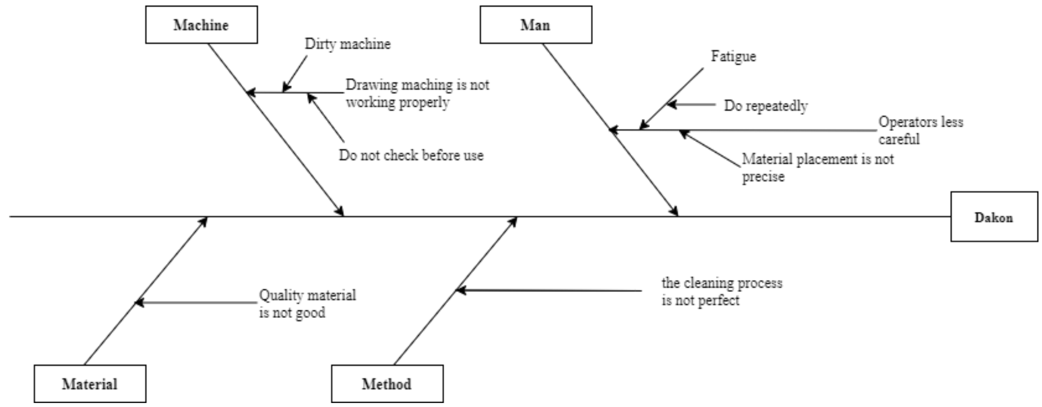

Figure 5 Fishbone Diagram 1

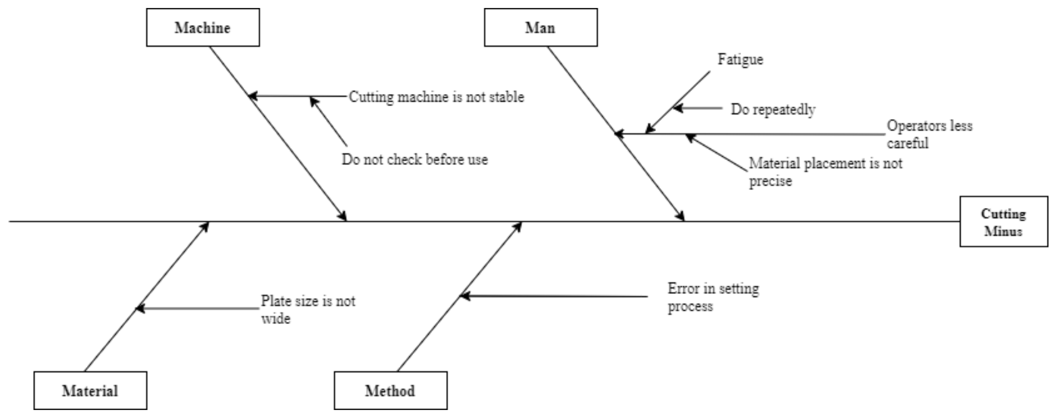

Figure 6 Fishbone Diagram 2

After the analysis, it can be seen that the defects that occur, namely dakon and cutting minus, occur due to several causes that have been described in the fishbone diagram above. Further actions will be discussed using the five whys approach, which will become a reference for improvements in the improvement stage.

5.3.1 Root Cause Analysis
From the data collection carried out, it is known that four main factors cause potential failures, as shown in the following Table 5.

Table 5. Root Cause Analysis (Man)

Defect	Why 1	Why 2	Why 3	Why 4	Why 5	Factors
Dakon	Man	Less careful during the production	Fatigue	Do repeatedly	Production target to be achieved	Man

From the analysis of Table 5, it is found that the factors that cause dakon defects are the human factor because the operator is less careful and tired from doing work repeatedly as a result of the production target being pursued.

Table 6. Root Cause Analysis (Method)

Defect	Why 1	Why 2	Why 3	Why 4	Why 5	Factors
Dakon	Method	The machine cleaning	Less careful during the	Hurried	Production target to be	Method

Defect	Why 1	Why 2	Why 3	Why 4	Why 5	Factors
		process is not perfect	machine cleaning		achieved	

Based on the analysis in Table 6 seen from the method factor, because the machine cleaning process is not perfect, this happens because the operator is not careful during the cleaning process and the operator is in a hurry when working due to a target that must be pursued. In this critical process, the causative factors are people and methods.

Table 7 Root Cause Analysis (Machine)

Defect	Why 1	Why 2	Why 3	Why 4	Why 5	Factors
Dakon	Machine	Draw machine not working perfectly	Dirty machine	Operators don't clean and check properly	Hurried	Man Method
			Not checked beforehand		Ignorance	Man Method

Based on the analysis in Table 7 seen from the machine factor, the draw frame is not functioning properly due to a dirty machine and not checking first. This is happened due to the operator not cleaning and checking the machine. Operators do not perform cleaning and checking due to target rush and ignorance. In this critical process, the related factors are humans and machines.

Table 8. Root Cause Analysis (Material)

Defect	Why 1	Why 2	Why 3	Why 4	Why 5	Factor
Dakon	Material	Material quality is not good	Supplier error	Stacked and rubbed with other materials	Less storage capacity	Method, Machin e
			Material is not good			

Based on Table 8 seen from the material factor, because the quality of the material is not good. Poor material quality is caused by supplier errors and poor storage due to stacking or rubbing against other materials. This condition happens due to a lack of material storage capacity.

Table 9. Root Cause Analysis (Man)

Defect	Why 1	Why 2	Why 3	Why 4	Why 5	Factor
Cutting Minus	Man	Less careful during the production	Fatigue	Do repeatedly	Production targets to be achieved	Machine Man
			Material placement is not precise	Hurried		

Based on the results from Table 9 seen from the human factor, fatigue and material placement are less precise due to the operator's lack of accuracy during the production process. This condition happened because the operator does it repeatedly and in a hurry due to many production targets.

Table 10. Root Cause Analysis (Method)

Defect	Why 1	Why 2	Why 3	Why 4	Why 5	Factor
Cutting Minus	Method	Error in the setting process	The operator doesn't understand the machine	Not reading instruction	Lack of socialization	Man Machine

Based on the results of Table 10, it can be seen from the method factor because of an error in the setting process. Errors in the setting process are caused by the operator who does not understand the machine and does not read the work instructions properly. A lack of socialization also causes this.

Table 11. Root Cause Analysis (Machine)

Defect	Why 1	Why 2	Why 3	Why 4	Why 5	Factor
Cutting Minus	Machine	The cutting machine is not stable	The operator doesn't check the machine first	Ignorance	Lack of socialization	Man Machine

Based on Table 11 seen from the machine factor, the error occurred because the cutting machine was less stable. After all, the operator did not check it first. The operator did not check because they did not know that the machine was thirsty for resetting. This condition happened was due to a lack of socialization and direction in the production process.

Table 12. Root Cause Analysis (Material)

Defect	Why 1	Why 2	Why 3	Why 4	Why 5	Factors
Cutting Minus	Material	Plate size is less or not the same	Supplier error	Didn't check when the item arrived	Lack of direction	Man Material

Based on Table 12 seen from the material factor, it occurs because the plate size is not appropriate, caused by supplier errors in shipping. This can also happen because the operator did not check when the goods arrived due to a lack of direction from the company.

5.4 Improve

Improve is the stage of making improvements to the causes of problems that occur in the CVT Ring. The improvements made can be seen in Table 13.

Table 13. Improvement

Problem / Category	Dakon	Cutting Minus
Man	Provide direction following existing work instructions so that operators carry out the production process by existing SOPs. Provide socialization and training on how to work Give rewards to employees if the results achieved are very satisfying and Profitable for the company.	Provide direction following existing work instructions so that operators carry out the production process by existing SOPs. Check the state of the material, whether it is precise or not. Give rewards to employees if the results achieved are very satisfying and profiTable for the company.
Machine	Carry out inspections of equipment and machines so that machines can work properly and perform regular machine cleaning and according to SOP.	Carry out inspections of equipment and machines to work properly and check the machine regularly and according to SOP.
Method	Provide information about methods and machines for employees because if there is a method that is not appropriate and is not understood by the operator, it will make the company lose.	Provide information about methods and machines for employees because if there are methods that are not appropriate and are not understood by the operator, the company will lose money.
Material	Improvements to the storage system in the storage warehouse, rearrange the material storage area and check the materials when they arrive from the supplier.	Re-confirm to the supplier regarding the materials to be sent and check the materials when they arrive from the supplier.

5.5 Control

The control stage is the last stage in the DMAIC method and is the control stage for the improvements that have been made in the improvement stage. The following are the steps that can be taken at the control stage:

1. Disseminate information to workers regarding standard operating procedures (SOPs) to understand and perform their work following existing SOPs and work well.
2. Ensure each operator reads the work instructions before carrying out the production process.
3. Supervise every operator who works in the production process every day.
4. Perform maintenance and checks on machines used regularly and periodically so that machines are maintained and reduce defects in the products produced.
5. Ensure that the material used is appropriate and the position of the material at the time of production is precise.
6. Ensure the health conditions of workers so that workers can work optimally and production results can run well.

6. Conclusion

From the results of practical work that has been carried out at PT. Denapella Lestari here are some things that can be summarized:

1. PT. Denapella Lestari is a company engaged in the Metal Stamping, Machining Parts, & Engineering Industry.
2. The method used to reduce defects in Mill Finish type aluminium profile products at PT. Denapella Lestari is a method with Pareto diagrams, histograms, p control charts, DPMO, fishbone diagrams, and why why analysis.
3. One of the problems faced by PT. Denapella Lestari is the number of defective Ring CVT products in 2020, which are 2262 pieces with 14 types of defects, and are at a value of 4.50σ.
4. Ring CVT production process at PT. Denapella Lestari consists of 5 types: blank & draw, sizing, trimming, cutting, and chamfer.
5. Based on the analysis results, there are 2 types of causes of defects with a large percentage, namely 50.40% is dakon and 29.93% the cause is cutting minus.

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Biography

Ignacia Claresta is a student at Tarumanagara University in Indonesia where she is majoring in industrial engineering. Her hobbies are watching movies and listening to music. She majored in industrial engineering because she was interested in the industrial sector, especially the textile industry. She has participated in several paper competitions.

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