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SIX SIGMA DMAIC ANALYSIS TO REDUCE VISUAL REJECT ON PLASTIC RAW MATERIALS IN LINE IQC SORTING USING SEVEN QUALITY TOOLS

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ABSTRACT

In the era of globalization of trade, the key to increasing a company's competitiveness is quality. Only companies that are able to produce world-class quality products can win global competition. PT. INT Indonesia (Company name has been disguised according to company policy) is a company operating in the Electronic Component Manufacturing and Assembly industry located in Batam, Indonesia. PT. INT Indonesia produces semi-finished hearing aid products and microphones for aviation, firefighting, aerobics and other needs. PT. INT Indonesia supplies products and services to the hearing health and communications industries. Six Sigma is a method used to increase productivity and profitability. The steps in processing this data use the DMAIC (Define, Measure, Analyze, Improve, Control) stages. Results of overcoming visual over rejects on plastic raw materials with Six Sigma DMAIC analysis using Seven Quality Tools at IQC Sorting Line PT. INT Indonesia in this research brought changes for the better, it can be seen from DPMO = 11,355.6 from 1 million Quantity to DPMO = 4,190.7 from 1 million Quantity. And the initial Sigma level of 3.778σ becomes a Sigma level of 4.136σ.

Keywords: Quality, Six Sigma, Quality Seven Tools.

1. INTRODUCTION

In the current era of globalization of trade, the key to increasing a company's competitiveness is quality. Only companies that are well managed and companies that are able to produce world-class quality products will survive and be able to win global competition.

The increasingly tight competition, a company must be able to implement the right business strategy in order to survive in the face of competition that occurs in the industrial world. In order to win the competition, business people must pay full attention to product quality. Quality is the single most important force that results in the company's success and growth, both in national and international markets. For this reason, every company must have an effective quality assurance program. With effective quality control, a company will produce high productivity, lower overall manufacturing costs and reduce the factors that cause production failures to a minimum.

PT. INT Indonesia (company name has been disguised according to company policy) is a company operating in the Electronic Component Manufacturing and Assembly industry located in Batam, Indonesia. PT. INT Indonesia was first established in Batam - Indonesia in July 2011. PT. INT Indonesia produces semi-finished hearing aid products and microphones for aviation, firefighting,

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aerobics and other needs. PT. INT Indonesia supplies products and services to the hearing health and communications industries. PT. INT Indonesia, precisely in Batam, is a wholly owned subsidiary of PT. INT U.S.A. after PT. INT Singapore. Company head office PT. INT is located in the U.S.A.

To produce products that satisfy customers and also benefit the company, PT. INT Indonesia must ensure that its products are of truly good quality according to predetermined specifications and with maximum production results, so that the company continues to survive in the face of intense competition in the market. The quality of an effective and efficient production process is an important thing that must be considered in order to achieve the quality of the product produced.

In an effort to improve quality, PT. INT Indonesia must first ensure that the raw materials used are truly of good quality. However, sometimes in reality, defective materials are still found, especially for plastic raw materials. This will affect the manufacturing process, especially the lack of availability of plastic materials. The plastic raw material referred to here is used as a shell/container or also known as Cover-Housing for semi-finished hearing aid products.

Data from October - December 2022 for the percentage of visual rejects for plastic raw materials reached 23%. Meanwhile, according to company policy, the percentage for visual rejects of plastic raw materials at IQC Sorting Line PT. INT Indonesia is allowed a maximum of 10%. This over reject certainly greatly affects the manufacturing process, especially the lack of availability of raw materials, which then results in delays in product delivery to customers. This of course greatly affects the company's performance in front of customers.

Table 1.1 Visual Reject Data for Plastic Materials October-December 2022

No.	Period (2022)	QTY Sorting	Qty OK After Sorting	Qty Reject After Sorting
1	October	2727	2266	461
2	November	1608	1242	366
3	December	846	498	348
Total		**5181**	**4006**	**1175**

2. LITERATURE REVIEW

2.1 Quality

Product quality is the capability, totality of features and characteristics of a product or service that depend on its ability to satisfy consumer needs expressed or implied by the products produced by the company.

2.2 Six Sigma quality control

The stages of implementing quality improvement with Six Sigma in research consist of five steps, namely using the DMAIC (Define, Measure, Analyze, Improve, Control) method, a continuous improvement process towards the Six Sigma target.

Table 2.1 Six Sigma DMAIC Stages

NO.	Six Sigma implementation stages	Information
1.	Define	Determining what processes will be evaluated. In accordance with the background of this research, the problem that will be evaluated in this research is reducing the number of visual rejects for plastic raw materials at IQC Sorting Line PT. INT Indonesia.

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2.	Measure	Determining quality characteristics, collecting data, taking measurements on data.
3.	Analyze	Detecting the main variables that influence defects and analyzing the causes of problems using Fishbone diagrams and verifying the root causes of problems directly to Line IQC Sorting PT. INT Indonesia to find corrective actions that can be taken.
4.	Improve	Implement corrective actions and identify corrective actions which constitute recommendations for solving problems.
5.	Control	Monitor all corrective actions to ensure they remain stable and in accordance with specification limits. Documenting research results. Make comparisons of data before research and after research. And if necessary, the company can standardize for improvements.

2.3 Defect Per Million Opportunities (DPMO)

DPMO is a measure of failure in Six Sigma, which indicates failures per million opportunities. The target of Six Sigma quality is 3.4 DPMO, it should not be interpreted as 3.4 defective output units out of a million output units produced. The steps that need to be taken in calculating DPMO are as follows:

a. Defect Per Unit (DPU) – The calculation of the DPU value can be seen below, namely:

$$\mathbf{DPU = D/U} \qquad \mathbf{(2.1)}$$

b. Total Opportunities (TOP) – The TOP value calculation can be seen below, namely:

$$\mathbf{TOP = UxOP} \qquad \mathbf{(2.2)}$$

c. Defect Per Opportunities (DPO) – The calculation of the DPO value can be seen below:

$$\mathbf{DPO = D/TOP} \qquad \mathbf{(2.3)}$$

d. Defect Per Million Opportunities (DPMO) – The DPMO value calculation can be seen below:

$$\mathbf{DPMO = DPO/1.000.000} \qquad \mathbf{(2.4)}$$

e. Sigma Level

Calculation of the sigma value conversion from Defect Per Million Opportunities (DPMO) to sigma value is carried out using Microsoft Excel with the Defect Per Million Opportunities (DPMO) conversion calculation formula as follows:

"*DPMO* = NORMSINV((1.000.000-*DPMO*)/1.000.000) +1,5"

According to Vincent Gaspersz (2018) the level of sigma achievement based on DPMO can be seen in table 1 below:

Tabel 2.2 Level Sigma

Sigma Achievement Level	Percentage of Non-Defective Products	***DPMO (Defect Per Million Opportunities)***	Category
1 *Sigma*	30,23%	697700	Company Is Very Uncompetitive
2 *Sigma*	69,13%	308700	Indonesian Industrial Average
3 *Sigma*	93,32%	66810	Industry Average
4 *Sigma*	99,379%	6210	Industry Average
5 *Sigma*	99,9767%	233	Japanese Industrial Average
6 *Sigma*	99,99966%	3,4	World Class Company

Source: Vincent Gaspersz, Avanti Fontana, 2018.

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2.4 Seven Quality Tools

QC Seven Tools are 7 (seven) basic tools used to solve problems related to quality. These 7 basic QC tools were first introduced by Kaoru Ishikawa in 1968. The seven tools are:

a. Check Sheet

A check sheet or inspection sheet is a tool for collecting and analyzing data which is presented in tabular form containing data on the number of goods produced and the types of nonconformities along with the quantities produced.

Check Sheet		
Type of Defect	**Qty Reject**	**Score**
Bend	𝍸 𝍸 𝍸 II	17
Black dot	𝍸 𝍸	10
Crack	𝍸 𝍸 𝍸	15
Dented	𝍸	5
Flashes	III	3
FM	𝍸 𝍸 I	11
Peel Off	𝍸 𝍸 IIII	14
Poor Coatting	𝍸 IIII	9
Scratches	III	3
White patch	𝍸 𝍸 𝍸	15
Total		102

Figure 2.1 Example of a Check Sheet

b. Run Chart

Stratification is an attempt to reduce or clarify problems into smaller groups or similar groups or into single elements of the problem.

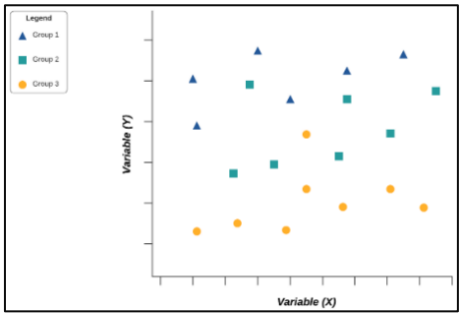

Figure 2.2 Example of a Run Chart

Sumber: https://www.lucidchart.com/blog/what-are-the-7-basic-quality-tools

c. Histogram

A histogram is a bar chart that shows a tabulation of data organized by size.

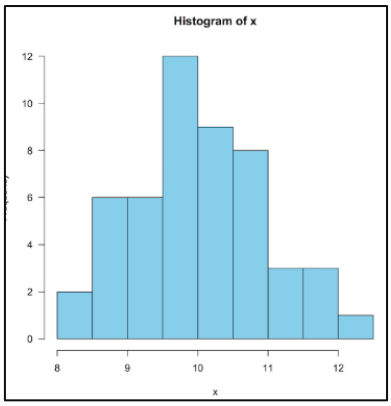

Figure 2.3 Example of a Histogram

Sumber: https://www.dataanalytics.org.uk/wp-content/uploads/2019/11/rplot-hist-basic-768x768.png

d. Control Chart

A control chart is a tool that is graphically used to monitor whether an activity can be accepted as a controlled process.

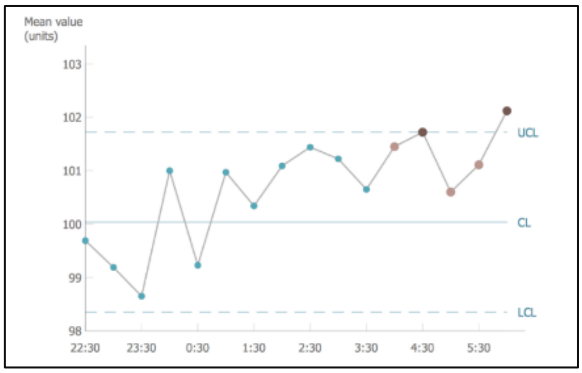

Figure 2.4 Example of a Control Chart

Sumber: https://www.conceptdraw.com/How-To-Guide/picture/Quality-Seven-Basic-Tools-Control-Chart-Example.png

e. Pareto Chart

The Pareto diagram was first introduced by Pareto and first used by Juran. Pareto diagrams are bar graphs and line graphs that illustrate the comparison of each type of data to the whole.

Figure 2.5 Example of a Pareto Chart

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Sumber:
https://eriskusnadi.files.wordpress.com/2012/03/pareto.png?w=490&h=294&zoom=2

f. Cause and Effect Diagram
This fishbone diagram also called cause and effect diagram and useful for showing factors the main factors that influence quality and have an impact on the problem we study.

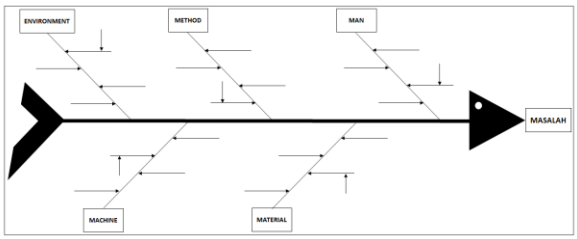

Figure 2.6 Example of a Fishbone Diagram

g. Scatter Diagram
A scatter diagram or also called a correlation map is a graph that displays the relationship between two variables, whether the relationship between the two variables is strong or not, namely between process factors that influence the process and product quality.

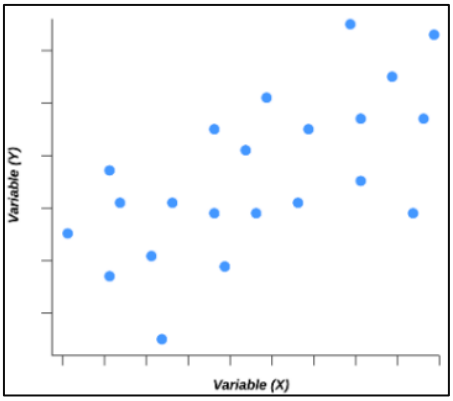

Figure 2.7 Example of a Scatter Diagram
Sumber:
https://d2slcw3kip6qmk.cloudfront.net/marketing/blog/2019Q4/basic-quality-tools/scatter-diagram-example.png

3. DATA COLLECTION AND PROCESSING

3.1 Data collection

Data collectionin this research was carried out by looking at documentation of data on the number of plastic visual material (raw materials) rejects that had been sorted from October to December 2022 directly at IQC Sorting Line PT. INT Indonesia. The data is attached in the following table:

Table 3.1 Visual Reject Data for Plastic Materials October-December 2022

No.	Periode (2022)	QTY Sorting	Qty OK After Sorting	Qty Reject After Sorting
1	October	2727	2266	461
2	November	1608	1242	366
3	December	846	498	348
Total		**5181**	**4006**	**1175**

3.2 Data processing

1) Define

This stage is the initial stage in the Six Sigma quality improvement program. In this research, several things were carried out in the Define stage, namely calculating the percentage of rejects before improvement. Looking at the experience from October - December 2022 shown in table 3.1 above, it is known that the percentage of visual rejects for plastic raw materials reached:

$$\% \boldsymbol{Reject} = \boldsymbol{Total\ reject} \div \boldsymbol{Total\ material\ Sorting}\ \boldsymbol{x}\ \mathbf{100}\%$$
$$\% \boldsymbol{Reject} = \mathbf{1175} \div \mathbf{5181}\ \boldsymbol{x}\ \mathbf{100}\%$$
$$\% \boldsymbol{Reject} = \mathbf{23}\%$$

Based on the calculations above, it can be seen that the overall reject percentage exceeds the company policy tolerance limit which allows a maximum percentage of visual rejects for plastic materials in the IQC Sorting Line of 10%. Critical To Quality (CTQ) visual reject of plastic material at IQC Sorting Line PT. INT Indonesia is 12 as shown in table 3.2 below:

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Table 3.2 Details of Reject Data Before Customer Confirmation

No.	QTY Sorting	Qty OK After Sorting	Qty Reject After Sorting	Reject Type	Total Reject Qty After Sorting	Percentage Per Rejection Type	Reject Percentage Frequency	Cumulative percentage of Rejects
1	5181	4006	1175	Black dot	233	4.50%	20%	20%
2				White patch	227	4.38%	19%	39%
3				FM	223	4.30%	19%	58%
4				Crack	178	3.44%	15%	73%
5				Scratches	92	1.78%	8%	81%
6				Dented	66	1.27%	6%	87%
7				Line Mark	59	1.14%	5%	92%
8				Bubble	59	1.14%	5%	97%
9				Flashes	11	0.21%	1%	98%
10				Poor Coatting	10	0.19%	1%	99%
11				Bend	9	0.17%	1%	99%
12				Peel Off	8	0.15%	1%	100%
Total					1175	23%	100%	

To make it easier to see the cumulative Reject Percentage in table 3.2, the following is depicted in the form of a Pareto diagram:

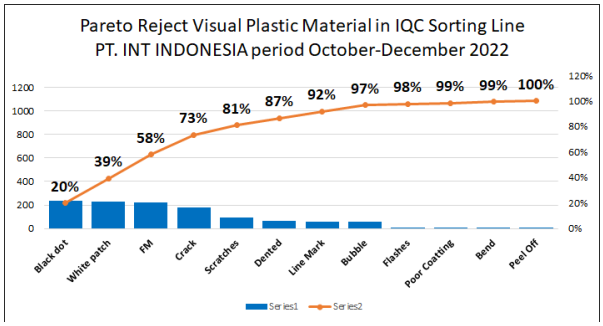

Figure 3.1 Pareto Diagram Before Customer Confirmation

Seeing the large percentage of visual rejects for plastic materials in IQC Sorting Line PT. INT Indonesia then applied one of the Six Sigma techniques, namely the voice of the consumer. This step is carried out by listening to consumer voices both externally and internally. By doing this, it will be easy to find out what can be developed or improved based on consumer desires. After confirmation by the customer and after sorting again, a visual reject percentage of plastic material is produced at IQC Sorting Line PT. INT Indonesia from October to December 2022 is as follows:

Table 3.3 Visual Reject Data After Customer Confirmation

No.	Period (2022)	QTY Sorting	Qty OK After Sorting	Qty Reject After Sorting
1	October	2727	2382	345
2	November	1608	1360	248
3	December	846	733	113
Total		**5181**	**4475**	**706**

From table 3.3 above, it can be seen the percentage value of visual rejects for plastic materials in IQC Sorting Line PT. INT Indonesia after being confirmed by the customer and after re-sorting is:

$$\% \textbf{\textit{Reject}} = \textbf{\textit{Total reject}} \div \textbf{\textit{Total material Sorting}}\ \textbf{\textit{x}}\ 100\%$$
$$\% \textbf{\textit{Reject}} = 3855 \div 5181\ \textbf{\textit{x}}\ 100\%$$
$$\% \textbf{\textit{Reject}} = 14\%$$

Based on the calculation above, this means that around 9% are false rejects or are still in the "acceptable" category by customers. From this data, it shows that there is visual over reject of plastic material in the IQC Sorting Line PT. INT Indonesia, which causes the visual reject percentage value of plastic material in the IQC Sorting Line PT. INT Indonesia reached 23%, exceeding the Company's maximum policy tolerance limit of 10%. However, the reject percentage of 14% still exceeds the tolerance limit, so corrective action needs to be taken to achieve more effective control of raw material quality. Detailed data is attached in the following table:

Table 3.4 Details of Reject Data After Customer Confirmation

No.	QTY Sorting	Qty OK After Sorting	Qty Reject After Sorting	Reject Type	Total Reject Qty After Sorting	Percentage Per Rejection Type	Reject Percentage Frequency	Cumulative percentage of Rejects
1	5181	4475	706	White patch	111	2.14%	16%	16%
2				Crack	101	1.95%	14%	30%
3				Black dot	85	1.64%	12%	42%
4				FM	84	1.62%	12%	54%
5				Scratches	64	1.24%	9%	63%
6				Bubble	62	1.20%	9%	72%
7				Dented	60	1.16%	8%	80%
8				Line Mark	41	0.79%	6%	86%
9				Bend	35	0.68%	5%	91%
10				Peel Off	29	0.56%	4%	95%
11				Poor Coatting	25	0.48%	4%	99%
12				Flashes	9	0.17%	1%	100%
Total					706	14%	100%	

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To make it easier to see the cumulative reject percentage in table 3.4, the following is depicted in the form of a Pareto diagram:

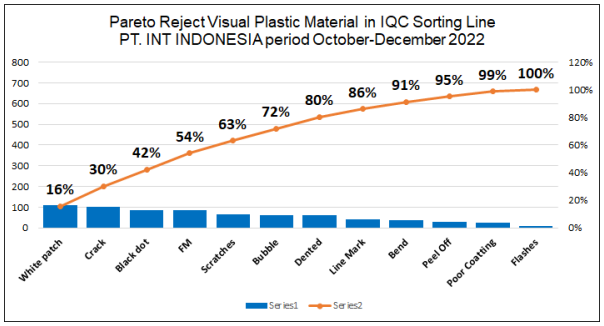

Figure 3.2 Pareto Diagram After Customer Confirmation

2) Measure

This stage is the data collection stage used to measure process performance. Referring to the visual reject data for plastic materials at IQC Sorting Line PT. INT Indonesia from October to December 2022 which is shown in table 3.3 with a percentage value of 14%, calculations will be carried out to determine the improvement plan:

a. Calculate the DPMO value and Sigma Capability value before repair

a) Determine the U value (number of units) before repair

The U value is equal to the number of units used in the research based on data from October to December 2022 which is shown in table 3.3. Based on table 3.3, the number of units measured in this study is:

U = Number of units studied

U = 5181 Pcs

b) Identify Opportunities (O) before improvement

The number of opportunities (O) is the same as the number of Critical To Quality (CTQ) or quality characteristics (causes of defects) previously determined. In this research, the characteristics (Opportunities) that cause visual rejection of plastic materials that have been sorted from October to December 2022 at the IQC Sorting Line PT. INT Indonesia is shown in Table 3.4.

Based on Table 3.4, the O (Opportunities) value is 12.

c) Calculating Defect (D) before repair

The number of defects calculated is the number of visual rejects of plastic materials that have been sorted from October to December 2022 at IQC Sorting Line PT. INT Indonesia, which is shown in table 3.3. From table 3.3 it is known:

D = Number of rejects

D = 706 Pcs

d) Calculating the Sigma capability value and the $DPMO$ (Defect Per Million Opportunities) value before repair

To calculate the value of $DPMO$ (Defect Per Million Opportunities) the formula is used:

$$\mathbf{DPMO} = \left(\frac{\mathbf{D}}{\mathbf{UXO}}\right)\mathbf{X1.000.000}$$

$$\mathbf{DPMO} = \left(\frac{\mathbf{706}}{\mathbf{5.181\ X\ 12}}\right)\mathbf{X\ 1.000.000}$$

$$\mathbf{DPMO} = \left(\frac{\mathbf{706}}{\mathbf{62.172}}\right)\mathbf{X\ 1.000.000}$$

$$\mathbf{DPMO} = \mathbf{0,0113555941581419\ X\ 1.000.000}$$

$$\mathbf{DPMO} = \mathbf{11.355,59415814193}$$

$$\mathbf{DPMO} = \mathbf{11.355,6}$$

Based on the calculations above, before repairs, the DPMO value = 11,355.6 was obtained from 1 million quantities of plastic material sorted from October to December 2022 at IQC Sorting Line PT. INT Indonesia and is at Sigma level: 3.778σ. There is a big possibility for companies to reach level 5 Sigma or even level 6 Sigma if the company knows and properly addresses the causes of defects.

b. Create a Histogram

The following image is a histogram of visual reject data for plastic materials at IQC Sorting Line PT. INT Indonesia from October to December 2022:

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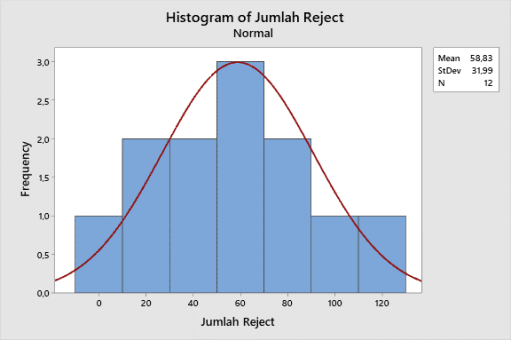

Figure 3.3 Histogram Before Improvement

The histogram graph above shows a distribution pattern resembling a bell, which means the data is normally distributed.

3) Analyze

Based on the visual reject percentage value of plastic material in the IQC Sorting Line PT. INT Indonesia from October to December 2022 is 14%, then analysis is carried out with Fhisbone to identify the root of the problem that causes the high percentage of plastic material rejects, to determine solutions for improvement. Below is a Fhisbone diagram from this research:

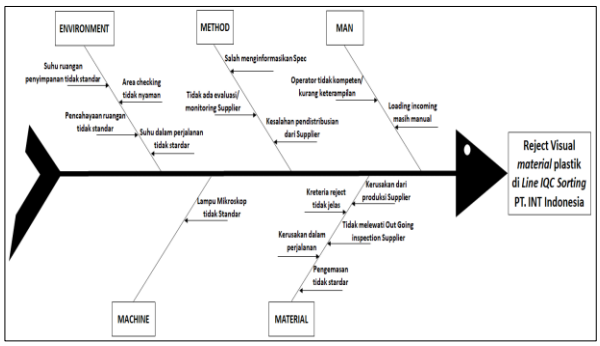

Figure 3.4 Fishbone diagram

The results of the analysis using the Fhisbone diagram found several factors that allow rejects to occur as shown in table 3.4 on plastic materials found at IQC Sorting Line PT. INT Indonesia, these factors are as follows:

Table 3.5 Prediction of Factors Causing Problems

No.	Factor	Problem
1	Man	Incoming loading is still manual & operators are incompetent/lacking skills.
2	Method	Distribution error from Supplier, No Supplier evaluation/monitoring & Wrong Spec information.
3	Machine	Microscope lights are not Standard.
4	Material	Damage from Supplier production, Not passing Supplier's Outgoing inspection, Non-standard packaging, Unclear reject criteria & Damage in transit.
5	Environment	The temperature during the trip is not standard, the checking area is not comfortable, the storage room temperature is not standard & the room lighting is not standard.

After verifying the root of the problem directly in the field, the factors that really caused plastic material rejects were found at IQC Sorting Line PT. INT Indonesia, namely:

Table 3.6 Real Root Factors of the Problem

No.	Factor	Problem
1	Method	There is no evaluation/monitoring of Suppliers.
2	Material	Material does not pass Outgoing Inspection Supplier, non-standard packaging & damage during transit.

4) Improve

At the improve or repair stage, it is provided to overcome the causes of rejects in plastic materials found at IQC Sorting Line PT. INT Indonesia, including the following:

a. Method

The problem caused by the method factor is that there is no Supplier evaluation/monitoring of the products produced, especially those sent to PT. INT Indonesia, so it has a big impact on the high

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percentage of visual rejects on plastic materials found at IQC Sorting Line PT. INT Indonesia.

b. Material
Problems caused by material factors are:
a) Material does not pass Outgoing Supplier inspection
rom this problem, it is known that all plastic raw materials sent to PT. INT Indonesia does not go through Out Going Supplier inspections, because the Supplier does not have an Inspector or Line Out Going.
b) Non-standard packaging
Apart from the factors above, the packaging for sending plastic materials is also not standard, where the materials are only packaged in one clear plastic clip with varying quantities and then put into a box.
c) Damage in transit
Because the packaging is not standard, so when there is shock and pressure that occurs at the time material in transit causes the sides of the material to collide (rub) together, resulting in rejects as mentioned in table 3.4.

c. Corrective action
Corrective action that can be taken is to inform the Supplier by making a Non-Conforming Material Report (NCMR), as well as requesting Corrective Action and Preventive Action from the Supplier. And the Corrective Action and Preventive Action provided by the Supplier are as follows.

5) Control

The control stage is the last stage of the DMAIC cycle. At this stage, control is carried out on what has been analyzed at the Analyze stage and then after implementing the proposed improvements at the Improve stage. Control is carried out by repeated measurements as in the Measure stage but after improvements have been made. What needs to be done at this stage is:

a. Calculate the percentage of rejects after repair
The following is the visual reject data for plastic materials at IQC Sorting Line PT. INT Indonesia after repairs from January to March 2023:

Table 3.9 Visual Reject Data for Plastic Materials January-March 2023

No.	Periode (2023)	QTY Sorting	Qty OK After Sorting	Qty Reject After Sorting
1	January	4519	4252	267
2	February	2727	2591	136
3	March	6475	6188	287
Total		**13721**	**13031**	**690**

From table 3.9 above, it can be seen the percentage value of visual rejects for plastic materials in IQC Sorting Line PT. INT Indonesia after repair is **(690:13721)100% = 5%.** Detailed data can be seen in the following table.

Table 3.10 Details of Reject Data After Repair

No.	QTY Sorting	Qty OK After Sorting	Qty Reject After Sorting	Reject Type	Total Reject Qty After Sorting	Percentage Per Rejection Type	Reject Percentage Frequency	Cumulative percentage of Rejects
1	13721	13031	690	Crack	119	0.90%	17%	17%
2				Black dot	95	0.70%	14%	31%
3				FM	90	0.70%	13%	44%
4				Scratches	72	0.50%	10%	54%
5				Flashes	70	0.50%	10%	65%
6				Peel Off	60	0.40%	9%	73%
7				Poor Coatting	59	0.40%	9%	82%
8				Dented	39	0.30%	6%	88%
9				Line Mark	35	0.30%	5%	93%
10				Bubble	23	0.20%	3%	96%
11				Bend	19	0.10%	3%	99%
12				White patch	9	0.10%	1%	100%
Total					690	5%	100%	

The cumulative percentage of Rejects in table 3.10 above is depicted in the form of a Pareto diagram below:

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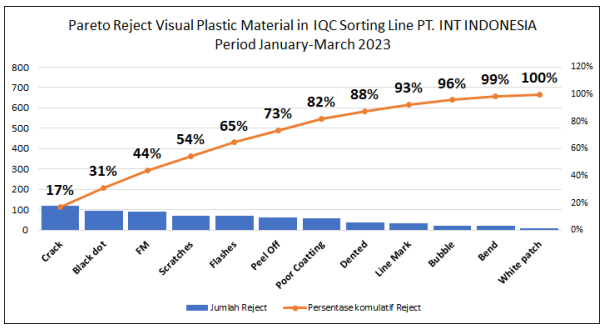

Figure 3.5 Pareto Diagram After Improvement

b. Calculate the Sigma Capability and DPMO values after improvement
   a) Determine the U value (number of units) after repair
      The U value is equal to the number of units used in the research based on data from January to March 2023 which is shown in Table 3.9, so the amount of production measured in this research is:
      U = Number of units studied
      U = 13721 Pcs
   b) Identify Opportunities (O) after improvement
      The number of opportunities (O) is equal to the number of Critical To Quality (CTQ) or quality characteristics (causes of defects) determined after improvement. In this research, the characteristics (Opportunities) that cause visual rejection of plastic materials that have been sorted from January to March 2023 at the IQC Sorting Line PT. INT Indonesia is shown in table 3.10. Based on table 3.10, the O (Opportunities) value is 12.
   c) Calculating Defect (D) after repair
      The number of defects calculated is the number of visual rejects of plastic materials that have been sorted from January to March 2023 at IQC Sorting Line PT. INT Indonesia, which is shown in table 3.9. From table 3.9 it is known:
      D = Number of rejects
      D = 690 Pcs
   d) Calculate the Sigma capability value and the $DPMO$ value after improvement

      To calculate the value of $DPMO$ (Defect Per Million Opportunities) the formula is used:

$$\mathbf{DPMO} = \left(\frac{\mathbf{D}}{\mathbf{UXO}}\right)\mathbf{X1.000.000}$$
$$\mathbf{DPMO} = \left(\frac{\mathbf{690}}{\mathbf{13.721\ X\ 12}}\right)\mathbf{X\ 1.000.000}$$
$$\mathbf{DPMO} = \left(\frac{\mathbf{690}}{\mathbf{164.652}}\right)\mathbf{X\ 1.000.000}$$
$$\mathbf{DPMO} = \mathbf{0,004190656657678\ X\ 1.000.000}$$
$$\mathbf{DPMO} = \mathbf{4.190,656657678012}$$
$$\mathbf{DPMO} = \mathbf{4.190,7}$$

      Based on the calculations above, after improvements, the DPMO value = 4,190.7 from 1 million quantities of plastic material sorted from January to March 2023 at IQC Sorting Line PT. INT Indonesia and is at Sigma level: 4.136σ = level 4 Sigma.

c. Create a Histogram after repair
   The following is a histogram that describes the characteristics of visual reject data for plastic materials at IQC Sorting Line PT. INT Indonesia after repair. The y-axis shows the data frequency of each class, while the x-axis shows the number of defects for each class or part. By using the Minitab software below, a histogram of the visual reject data for plastic materials on the IQC Sorting Line will be displayed PT. INT Indonesia from January to March 2023:

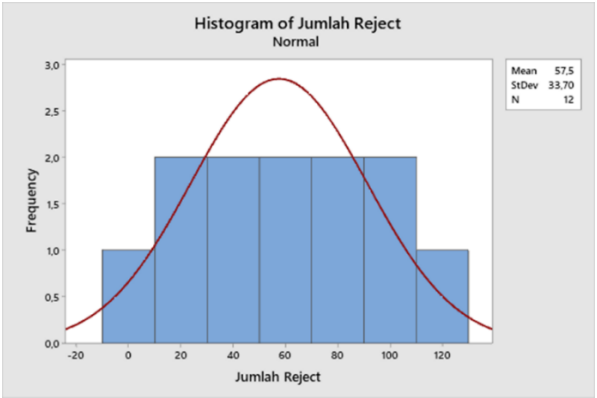

Figure 3.6 Histogram After Repair

Based on the output chart display above, the histogram graph provides a bell-like

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distribution pattern, which means the data is normally distributed.

d. Recommendations for improvement
From this control stage, the author recommends that companies remain consistent in carrying out quality improvement actions to achieve maximum results. Actions that can be taken are as follows:
a) PT. INT Indonesia will request Corrective Action and Preventive Action from Suppliers when an increase in rejected material is found.
b) Suppliers are committed to maintaining Line In-Process Quality Control (IPQC) and Line Out-going Quality Control (OQC).
c) Consistent packaging of plastic material from supplier, storage to production using trays.
d) Consistently, all plastic materials sent by Suppliers must go through Outgoing Quality Control, deliveries include an Outgoing Inspection Report (OIR) and Certificate of Conformance (COC).
e) The inside of the Supplier's shipping box will be given a layer of Bubble Plastic (all around) and provide a fairly solid support during delivery.
f) Reject material resulting from sorting at PT. INT Indonesia will be returned to the Supplier to be replaced with a new one.

4. DISCUSSION AND RESEARCH RESULTS

4.1 Discussion

This chapter will discuss the comparison of research results before and after improvements were carried out using the Six Sigma DMAIC method.

a. Comparison of the percentage of rejects before and after improvement

Table 4.1 Visual Reject Data for Plastic Materials October-December 2022

No.	Period (2022)	QTY Sorting	Qty OK After Sorting	Qty Reject After Sorting
1	October	2727	2382	345
2	November	1608	1360	248
3	December	846	733	113
Total		**5181**	**4475**	**706**

Based on the data in Table 4.1, the percentage value of plastic visual material (raw material) rejects in the IQC Sorting Line PT. INT Indonesia, from October to December 2022 is **(706:5181)100% = 14%**.

Table 4.2 Visual Reject Data for Plastic Materials January-March 2023

No.	Periode (2023)	QTY Sorting	Qty OK After Sorting	Qty Reject After Sorting
1	January	4519	4252	267
2	February	2727	2591	136
3	March	6475	6188	287
Total		**13721**	**13031**	**690**

Based on the data in Table 4.2, the percentage of visual rejects for plastic materials in the IQC Sorting Line PT. INT Indonesia after improvement, namely from January to March 2023 is **(690:13721)100% = 5%**. Comparison of data on the percentage of visual rejects for plastic materials at IQC Sorting Line PT. INT Indonesia before improvement and after improvement saw a decrease from 14% to 5%. This change certainly has a good impact on efforts to reduce visual rejects on plastic raw materials at IQC Sorting Line PT. INT Indonesia.

b. Comparison of Pareto Diagrams before and after improvements

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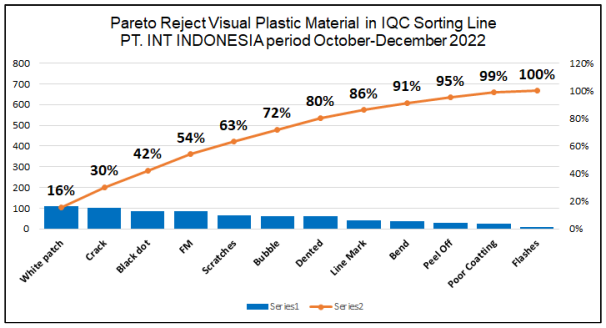

Figure 4.1 Pareto Diagram Before Improvement

Figure 4.1 above is a depiction of the cumulative percentage of visual rejects for plastic materials at IQC Sorting Line PT. INT Indonesia before taking corrective action in the form of a Pareto diagram.

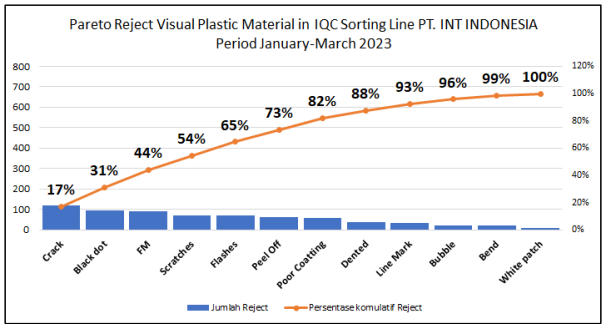

Figure 4.2 Pareto Diagram After Improvement

Figure 4.2 above is a depiction of the cumulative percentage of visual rejects for plastic materials at IQC Sorting Line PT. INT Indonesia after carrying out corrective action in the form of a Pareto diagram. From the comparison of Figure 4.1 with Figure 4.2 above, it can be seen that the order of reject types has changed.

c. Comparison of Sigma's *DPMO* and capabilities before and after improvements

Based on the calculations carried out in Chapter 4, before repairs the values obtained are:
*DPMO = 11.355,6 from 1 million Quantity material
*Sigma level: 3.778σ
*Which is illustrated through the following graph:

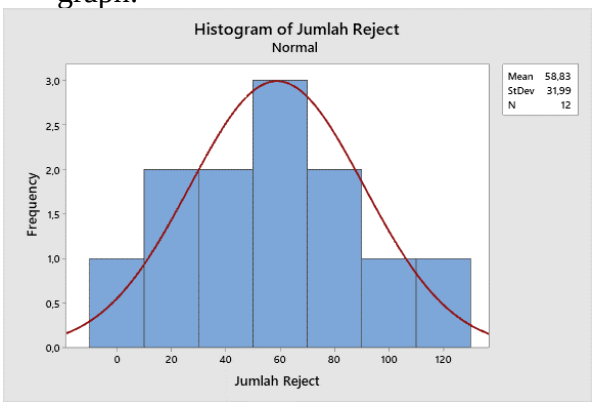

Figure 4.3 Sigma level graph: 3.778σ

Based on the calculations carried out in Chapter 4, after improvements the values obtained are:
*DPMO = 4,190.7 from 1 million Quantity material
*Sigma level: 4.136σ
*Which is illustrated by the following graph:

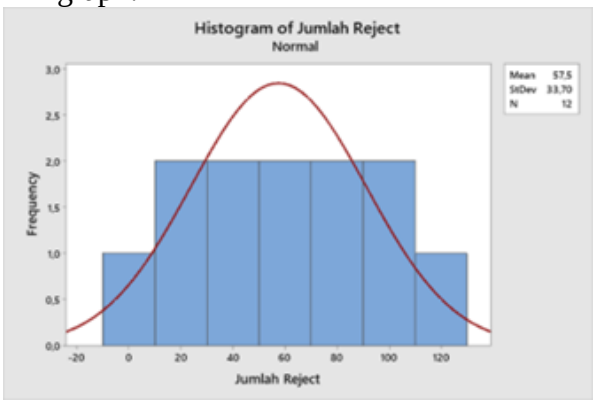

Figure 4.4 Sigma level graph: 4.136σ

These results show that the results after improvements are still at the 4 Sigma level, but the results still show a good increase, namely DPMO = 11,355.6 from 1 million to DPMO = 4,190.7 from 1 million and from Sigma level: 3,778σ to Sigma level: 4.136σ.

4.2 Research result

Of all the research activities "Six Sigma DMAIC to Reduce Visual Reject in Plastic Raw Materials on the IQC Sorting Line Using Seven Quality Tools" carried out at PT. INT Indonesia obtained quite effective results, but further quality control activities need to be

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carried out to reach level 5 Sigma or even level 6 Sigma.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

Based on the analysis and discussion regarding **"Six Sigma DMAIC Analysis to Reduce Visual Rejects on Plastic Raw Materials on the IQC Sorting Line Using Seven Quality Tools"** from January to March 2023, it can be concluded that:

a. Factors that influence the occurrence of visual over-reject on plastic raw materials at IQC Sorting Line PT. INT Indonesia is that there is no Supplier evaluation/monitoring of products sent to PT. INT Indonesia, material did not pass Outgoing Supplier inspection, packaging was not standard and was damaged in transit.

b. Corrective actions taken to reduce the number of visual rejects on plastic raw materials at IQC Sorting Line PT. INT Indonesia is PT. INT Indonesia is as follows:
   a) PT. INT Indonesia will request Corrective Action and Preventive Action from Suppliers when an increase in rejected material is found.
   b) The supplier is committed to maintaining Line In-Process Quality Control (IPQC) and Line Out-going Quality Control (OQC).
   c) Consistent packaging of plastic materials from supplier, storage to production using trays.
   d) Consistency for all plastic materials sent by Suppliers must go through Outgoing Quality Control, shipments include an Outgoing Inspection Report (OIR) and Certificate of Conformance (COC).
   e) The inside of the Supplier's shipping box will be given a layer of Bubble Plastic (all around) and provide a fairly solid support during delivery.
   f) Reject material resulting from sorting at PT. INT Indonesia will be returned to the Supplier to be replaced with a new one.

c. The results of overcoming visual overrejection in this research have brought changes in a better direction, which can be seen from the changes:
   a) DPMO = 11,355.6 from 1 million Quantity becomes DPMO = 4,190.7 from 1 million Quantity.
   b) The initial Sigma level of 3.778σ becomes a Sigma level of 4.136σ.

5.2 Suggestion

The advice that the author can give based on this research is to get maximum results, namely level 5 Sigma or even level 6 Sigma in controlling the quality of plastic materials (raw materials) at IQC Sorting Line PT. INT Indonesia which will be used in making products, PT. INT Indonesia must continuously carry out continuous improvement actions and it would be better if PT. INT Indonesia can work together with Suppliers in controlling these materials.

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