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Analysis of Opaque, Peel-Off and Flex Rejects in the Electro Plating Process Using the Six Sigma Dmaic Method

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Abstract:- The modern manufacturing industry is faced with increasing pressure to achieve high levels of quality while remaining efficient in its production processes. One of the challenges faced by PT. Plating services in electroplating production have a high reject rate, which can cause increased costs and have a negative impact on the company's reputation. PT. Jasa Plating in the production process still has a high number of rejects, the rejects are dominated by opaque, peel-off and spots. PT. Plating services for each production contribute a high average of 2% defects per day, DPMO 20,000 and Sigma value 3.55. Quite a few rejections resulted in a decrease in turnover and increased production costs. The costs incurred due to these rejects are an average of Rp. 1,268,593 per day and an average of Rp. 35,698,907 per month as a result of data collection from January – September 2023. In this business process, this is very detrimental for the company. The aim of this research is to suppress blurry rejects, peel-offs and spots in the electro plating process at PT. Plating Services. The steps taken in conducting research include: identification stage, data collection and processing, analysis and recommendations for improvement, and conclusions. The method used in this research is the Six Sigma DMAIC (Define, Measure, Analysis, Improvement, Control) method. Through analysis, you can find several factors that cause high reject rates, including operational errors, discrepancies in the production process, or raw material quality problems. After implementing the improvement plan, then evaluate the results. This can include re-measuring the DPMO, analysis of the resulting products to see a decrease in reject rates, and comparisons between before and after implementing improvements. From the comparison results after the repairs were carried out, the data before the repairs were carried out, the NG amount was 1.99%, the DPMO was 6,646 and the Sigma value was 3.98. After improvements to NG 0.84%, DPMO 2,791 sigma value 4.28. Factors causing high levels of blurring, peel-off and spots, namely insufficient or excessive cleaning of the metal surface before the electroplating process, can cause problems such as peel-off. Contamination of the electroplating solution by foreign materials can cause blurring and flecks in the final layer. Machinery or equipment that is not properly calibrated, or experiences wear and tear, can produce products that do not meet standards. Variations in temperature, time, or electric current in the electroplating process can produce inconsistent coatings. Carefully monitor and control process-parameters to ensure stability.

Keywords:- *Electro Plating, Reject, Six Sigma DMAIC, DPMO.*

I. INTRODUCTION

An electro plating company is a company that operates in the metal plating sector, almost 75% of motor vehicle spare parts are coated with an electro plating process. The modern manufacturing industry is faced with increasing pressure to achieve high levels of quality while remaining efficient in its production processes. One of the challenges faced by PT. Plating Services in electro plating production is a high rejection rate, which can lead to increased costs and have a negative impact on the company's reputation.

Electro plating is an important process in the manufacturing industry where a layer of metal is deposited on the surface of a workpiece to provide protection, improve appearance and impart certain properties. Even though this process has become standard in various industries such as automotive, electronics and jewelry, problems often occur which result in electro plating products being rejected due to rejection in the form of blurring, peel-off and spots on the metal layer which should be of high quality. This problem affects production quality and customer satisfaction.[1]

PT. Jasa Plating in the production process still has high rejects, rejects that are considered opaque, peel-off and spots. PT. Plating services for each production contribute a high average of 2% defects per day, DPMO 20,000 and Sigma value 3.55. Quite a few rejections resulted in a decrease in turnover and increased production costs. The costs incurred due to these rejects are an average of Rp. 1,268,593 per day and an average of Rp. 35,698,907 per month as a result of data collection from January – September 2023. In this business process, this is very detrimental for the company. Thus, it is hoped that this research can help the company PT. Plating Services is able to optimize processes, improve product quality, and reduce costs associated with high rejection rates and can provide valuable guidance for companies to achieve higher levels of quality in electroplating production at PT. Plating Services.

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II. LITERATURE STUDY

This literacy study will explain the quality, basic theory and materials used in this research. One of the methodologies in the sixsigma concept is DMAIC (Define, Measure, Analyze, Improvement, Control). This sixsigma methodology is a line of thinking that is sequentially carried out to improve processes in the system.

A. Quality

Product quality is a product's ability to fulfill every consumer need in accordance with the consumer's needs and desires. The quality or quality of a product is one of the important factors that influences the decisions desired by consumers. Continuous quality control is one way to reduce failures in the production process so that it can reduce the number of damaged products and is also used to detect errors in the production process.[2]

B. Six Sigma

Six Sigma is a methodology that is popular throughout the world. Usually, Six Sigma is used to carry out continuous process improvements and improvements as well as quality control. Six Sigma is that if a company can measure how many defects it has in a process, then the company can systematically address how to suppress and place the company close to zero-defect. The goal of this method is to improve performance and reduce the possibility of errors. In the end, Six Sigma is able to create a company process with better production quality, increase profits, and even increase employee morale. Six Sigma gets its name from the words "six" which means six (6) and "sigma" which means standard deviation, which is a measure of data distribution in statistics. This methodology comes from the bell curve in statistics, where one sigma represents one standard deviation from the mean or mean. If a process has six sigma consisting of three sigma above and below, the failure rate is considered low. In simple terms, the higher the sigma value, the smaller the possibility of a process defect.[3]

In the Six Sigma concept, all forms of inefficiency or waste must be eliminated. Therefore, companies must build a company culture that is flexible and responsive, especially in making changes to procedures to make them more effective. All employees must be ready to make changes quickly. In fact, for a Six Sigma strategy to run smoothly, it requires a strong infrastructure layer. Apart from that, in these infrastructure layers, workers are also needed to hold certain positions. The holder of this position is tasked with ensuring that each department in the company receives the resources they need.[4].

C. Root Cause Analysis (RCA)

RCA is a problemsolving method used to identify the root cause of a problem. The use of the RCA method is based on the philosophy that to overcome a problem it must be done by eliminating the root of the problem which is the main cause of the problem. There are five types of problem classification in the RCA method. which is usually abbreviated to 5M, namely Man, Machine, Method, Material, and Management System. This method can also be used to help build basic knowledge in systems related to issues regarding product reliability, processes, availability and maintenance. By carrying out corrective treatment at the root of a problem, it is hoped that problems with the same root problem will not recur.[5]

D. DMAIC (Define, Measure, Analyze, Improvement, Control)

DMAIC is a data-driven method. The goal is to develop existing products or services to increase consumer satisfaction. Typically, DMAIC is used for manufacturing a product or delivering a service. DMAIC consists of 5 stages. The following are the stages in this methodology:

- *Define*

This stage is the initial stage in the continuous improvement process, in this stage determine or identify clearly and in detail what you want to achieve, determine a theme, set targets, SMART, create a work plan, etc. Tools that can be used in the define stage are SIPOC (Suppliers, Input, Process, Output, Customer). SIPOC is used to identify the needs of all stakeholders, the resources needed during the process. This Define stage is very important because it helps in a good understanding of the problem to be solved and provides a clear direction for the next DMAIC project.[6]

- *Measure*

The Measure stage is the stage where you start collecting data related to the problem or process that is being improved. This data must be relevant to the project objectives and problems identified in the Define stage. In this stage, get a detailed picture of the main problem you want to improve, namely calculating the DPMO value and sigma level. Activities carried out during this stage include calculating the company's sigma level, calculating process capabilities, RCA (Root Cause Analysis), MSA (Measurement System Analysis). The purpose of carrying out this Measure is to identify critical parts of the process scope that will be improved.[7]

- *Analysis*

At this stage, carry out an in-depth analysis of the data that has been collected at the Measure stage to identify the root causes of the problem and understand the factors that influence the process. The tools used are fishbone diagrams (cause and effect diagrams), Pareto diagrams, 5W1H. Selection of improvements is not only based on intuition and subjectivity alone, but also based on data that has been previously processed.[8]

- *Improvement*

At this stage the focus is on designing, testing and implementing changes aimed at overcoming production quality problems that have been identified in the previous stage. Improvement will have various impacts on the overall process. It is not certain that improvements to one process will also have a good impact on other processes. For this reason, various improvement scenarios are needed which will later be compared with the company's capabilities regarding available resources.[9]

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➢ *Control*

At this stage the focus is on maintaining the improvements that have been implemented so that they are sustainable and developing a control system to prevent the same reject problem from recurring. Control is carried out using Checksheet, X-R Chart and P control chart.

E. Pareto Chart

The existence of the Pareto Principle will of course be related to the Pareto Diagram. A Pareto diagram is a bar diagram combined with a line diagram to show a parameter being measured. It can be a frequency of events or a certain value, so that the dominant parameter can be known. The Pareto diagram has become a standard method for quality control in order to obtain maximum results. The Pareto diagram is also considered a simple approach that is easy for workers to understand (even if they are not educated), and can be used as a solution tool in complex fields. In the Pareto Diagram, there is an image that sorts the data classification from left to right, according to the highest ranking to the lowest ranking. Pareto diagrams can also function to compare process conditions, for example the existence of process incompatibilities. The success of the Pareto diagram is determined by the participation of personnel in the situation being observed, with visible financial impacts in the process of improving the situation and setting appropriate goals.[10]

F. DPMO (Defects Per Million Opportunities)

DPMO in six sigma is an abbreviation of Defects-Per-Million-Opportunities. It is a probabilistic measure of the error rate of a business process or product. In other words, it measures how efficient and effective a process or product is. It measures how good a process is at committing errors.[11] This is also called NPMO or Nonconformities per Million Opportunities.

➢ *The DPMO Calculator Formula is as follows:*

$$DPMO = \frac{1,000,000 \times \text{number of defects}}{\text{number of units} \times \text{number of Defects opportunities per unit}}$$

G. Control Chart (p Chart)

This p Chart is used to monitor characteristics that have discrete values by calculating them, such as streaks, color and taste. The attribute data statistical process quality p Chart can minimize these limitations by providing all quality information to reduce costs. Proportion control chart (p-chart) The sample taken must be constant and the items are assumed to be independent. This p chart is a versatile control chart. [12]. Used to control quality characteristic capabilities. p charts can also be used to measure the quality of a machine operator, a work station, a department. p charts are used for attribute data with unequal lot sizes. The p chart is based on the binomial distribution.

$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} \qquad CL = \bar{p}\,\frac{\sum np}{N} \times 100\% \qquad LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

H. SPC (Statistical Process Control)

Statistical Process Control is a statistical technique that is widely used to ensure that processes meet standards. In other words, Statistical Process Control is a process used to monitor standards, make measurements and take corrective action while a product or service is being produced. Quality Control Tools In carrying out statistical quality control (Statistical Process Control) there are several tools that are used. The main tools used are known as seven tools. The following are several explanations regarding the types of seven tools[5]:

- Checksheet (Check Sheet). Checksheets are tools that are often used to count how often something happens and are often used in collecting and recording data. The data that has been collected is then entered into a graph such as a Pareto diagram or histogram, and then analyzed.
- Pareto Diagram. This diagram is used to determine the importance or priority of categories of events arranged according to their size or the causes to be analyzed, so as to focus attention on the causes that have the greatest impact.
- Control Chart (Control Chart). A control chart is a graph used to determine whether a process is in a state of in control or out of control. Control limits include upper limits (upper control limits) and lower limits (lower control limits) which can describe the expected performance in a consistent process.
- Scatter Diagram. This diagram is also often called a correlation map because it shows the strength and weakness of the relationship between two variables. This variable is a process that influences product quality. Apart from showing the strength and weakness of the relationship between the two variables, this diagram also shows the positive, negative or no relationship at all between the two variables. The variables shown can be quality characteristics with factors that influence them.
- Histogram This tool is used to determine variations in the problem. The form of this tool is in the form of a bar chart arranged based on size. By using a histogram, we are able to provide an overview of the population because the histogram shows the characteristics of data which is divided into several categories.
- Flow Chart. This diagram shows it graphically in the form of boxes and interconnected lines. By using this tool we are able to find out the steps or sequence of a process being carried out.
- Cause and Effect Diagram (Cause and Effect Diagram). This diagram is also called a Fishbone diagram, because it is shaped like a fish skeleton. Cause and Effect Diagrams are used to identify categories and subcategories of causes that influence a particular quality characteristic. The main causal factors can be grouped into material, machine, man, method, and environment.[5]

III. RESEARCH METHODS

This research uses a quantitative research design. What is meant by quantitative research here is the method used to answer research problems using numbers, statistical

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processing, structure and control experiments. The method used in this research is the Six Sigma DMAIC method. The aim of this research is to suppress blurry rejects, peel-offs and spots in the electro plating process at PT. Plating Services. The steps taken in conducting research include: identification stage, data collection and processing, analysis and improvement with Six Sigma DMAIC, and conclusions. The flowchart of this research is in Figure .1 below:

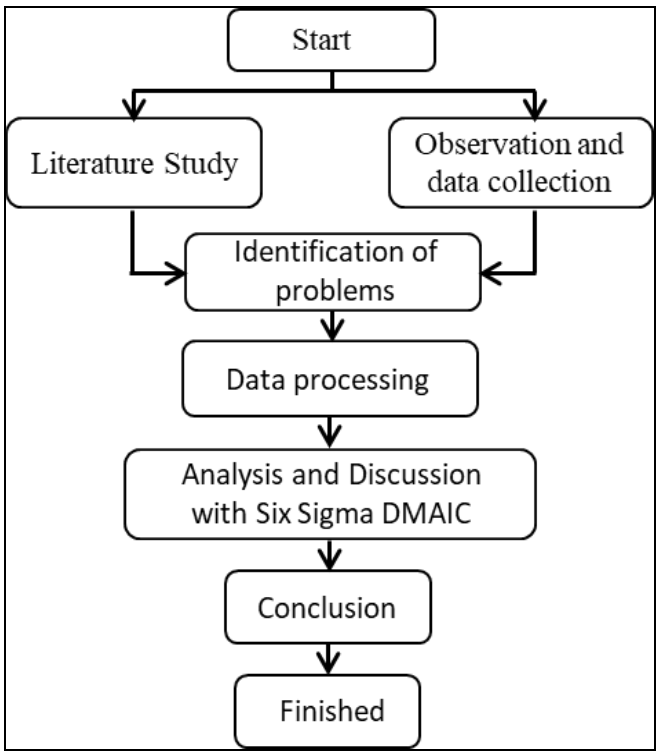

Fig. 1 Research Flowchart

➢ *Identification of Problems*

This stage explains the stages involved in identifying existing problems within the company and the general framework for resolving these problems.

- Literacy Study. This stage is carried out to obtain a suitable method to use as a reference in solving existing problems within the company. Theories and methods are obtained by searching for and reading literature related to the problem researched by the author.
- Observation and data collection. At this stage, the necessary data will be searched for regarding problems occurring in the company. The data taken can be secondary data or primary data. Secondary data is data obtained from existing reports in the company, while primary data is data taken directly in the section that is the object of observation or by interviewing employees in the section concerned.
- Identify the problem. The activities carried out in this stage are conducting interviews with employees in the section that will be examined and making direct observations of production. This activity is intended to find out problems that exist in production. The results obtained from this stage are in the form of a formulation of the research problem.
- Data Processing. After the data was obtained, data processing was carried out using the Six Sigma method.

➢ *Data Collection.*

In this research, the object of research is suppressing rejects resulting from electroplating production. The data required is production reject data and is obtained by taking production data for 9 months or from January - September 2023. At the data collection stage, the activities carried out include the following:

- Collection of Company Performance Data. At this stage, the necessary data will be searched regarding the performance and achievements produced by production activities within the company. The data taken can be secondary data or primary data. Secondary data is data obtained from existing reports in the company, while primary data is data taken directly in the section that is the object of observation or by interviewing employees in the section concerned.
- Make a comparison between company achievements and targets. At this stage, a comparison will be made between previously obtained achievement data and the targets set by the company. From this comparison, a gap will be obtained between the target and the actual achievement of the company concerned.
- Identify rejects. If there is a gap in the comparison between the target and reality, then identification of the reject that causes the gap must be carried out. Reject identification is very important as a basis for future improvement.

IV. RESULTS AND DISCUSSION

Results of problem identification at PT. Plating Services in the electro plating production process has a large number of rejects with an average daily production of 167,529 pcs and rejects of 3,351 pcs with a sigma value of 3.55. With this case, improvements are needed to reduce the number of rejects using the six sigma method so that the sigma value can approach 6 sigma.

A. Define Stage

The following is the average daily reject data generated at PT. Plating Services:

Table 1 Daily Average Reject Data

Reject Type	Qty	%	% Cummulative
Opaque	288,443	40%	40%
Peel Off	234,232	33%	73%
Flex	192,991	27%	100%

Production	Reject	% NG	Pcs/ loading	loading/ 2shift
4,540,620	94,299	2.08%	1,400	120

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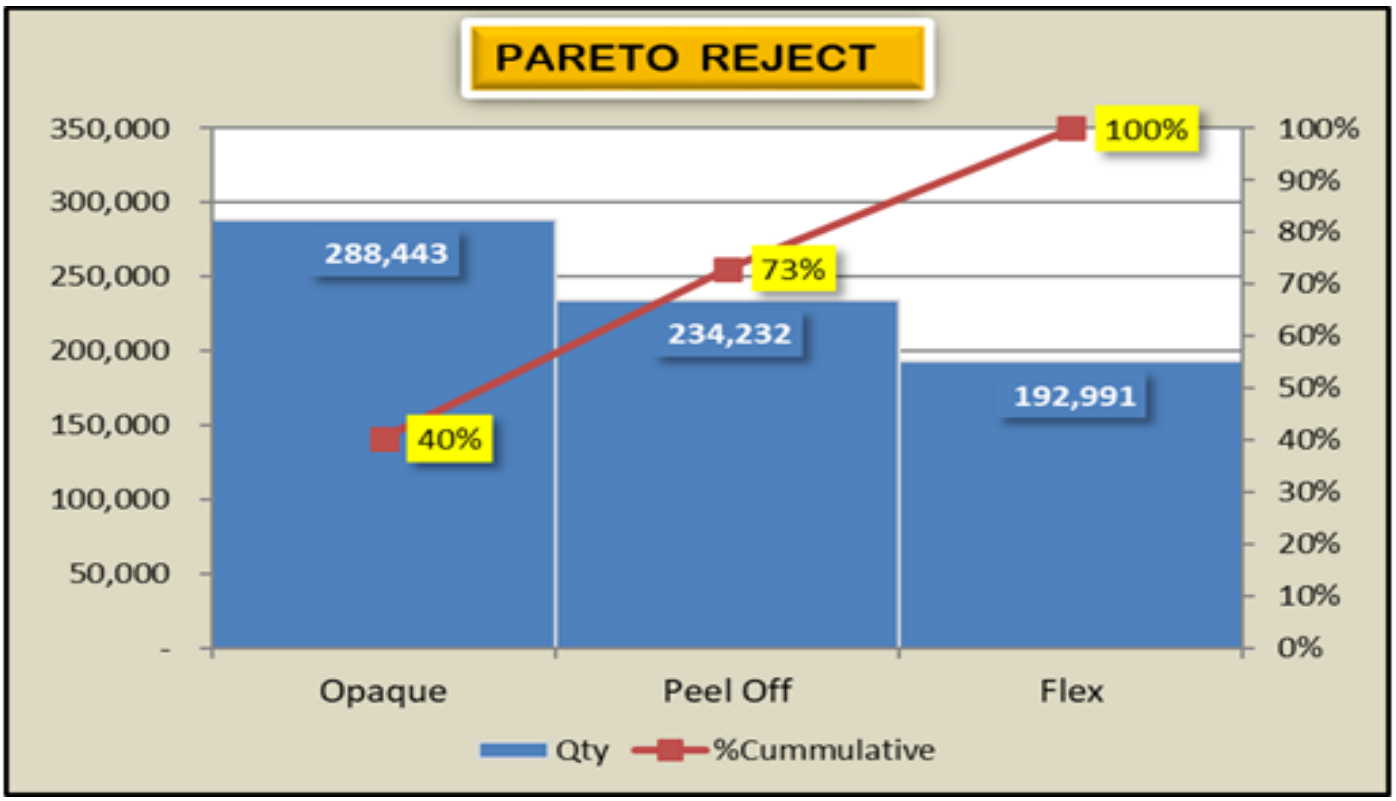

Fig 2 Pareto Diagram

Table 2 Reject Data January-September 2023

Items	2023									Amount
	Jan	Feb	Mar	Apr	Mei	Jun	Jul	Aug	Sep	
Production	4,540,620	4,029,900	4,518,010	2,433,900	4,214,770	4,333,140	4,311,860	4,540,620	4,474,120	**37,396,940**
Good	4,446,056	3,943,722	4,427,663	2,388,858	4,114,711	4,281,909	4,247,115	4,446,321	4,384,919	**36,681,274**
Opaque	35,369	33,127	33,735	17,267	48,510	20,302	25,813	38,024	36,296	**288,443**
Peel-off	31,352	27,729	30,576	15,559	30,436	17,281	20,882	29,929	30,488	**234,232**
Flex	27,843	25,322	26,036	12,216	21,113	13,648	18,050	26,346	22,417	**192,991**
Not Good	94,564	86,178	90,347	45,042	100,059	51,231	64,745	94,299	89,201	**715,666**
%NG	2.08%	2.14%	2.00%	1.85%	2.37%	1.18%	1.50%	2.08%	1.99%	**17.20%**
DPMO	20,826	21,385	19,997	18,506	23,740	11,823	15,016	20,768	19,937	**19,111**
σ	3.54	3.53	3.56	3.59	3.48	3.76	3.67	3.53	3.55	**3.58**
Working days	26	23	26	14	24	25	25	26	26	**24**

➢ *SIPOC (Supplay Input Process Output Customer).*

The SIPOC diagram is useful for identifying problem areas and analyzing process problems. Regarding the SIPOC diagram at PT. Plating services are goods from customers who have arrived and the quality is checked randomly on parts that are rusty, defective, or of different types. If the part has a discrepancy, confirm with the customer for further action. If it passes the inspection, the part is recorded and the electro plating process continues. After completing the electro plating process, a visual check from QC is carried out on the plating results. then the part is sent to the customer. In the electro plating process, there are many factors or elements needed to achieve good plating results. In this SIPOC diagram, problems arise at the Process stage. The dominant factor in the process stage occurs in the solution used in the plating process, control of solution concentration and other process support that needs to be considered. The following is a SIPOC diagram at PT. Plating Service.

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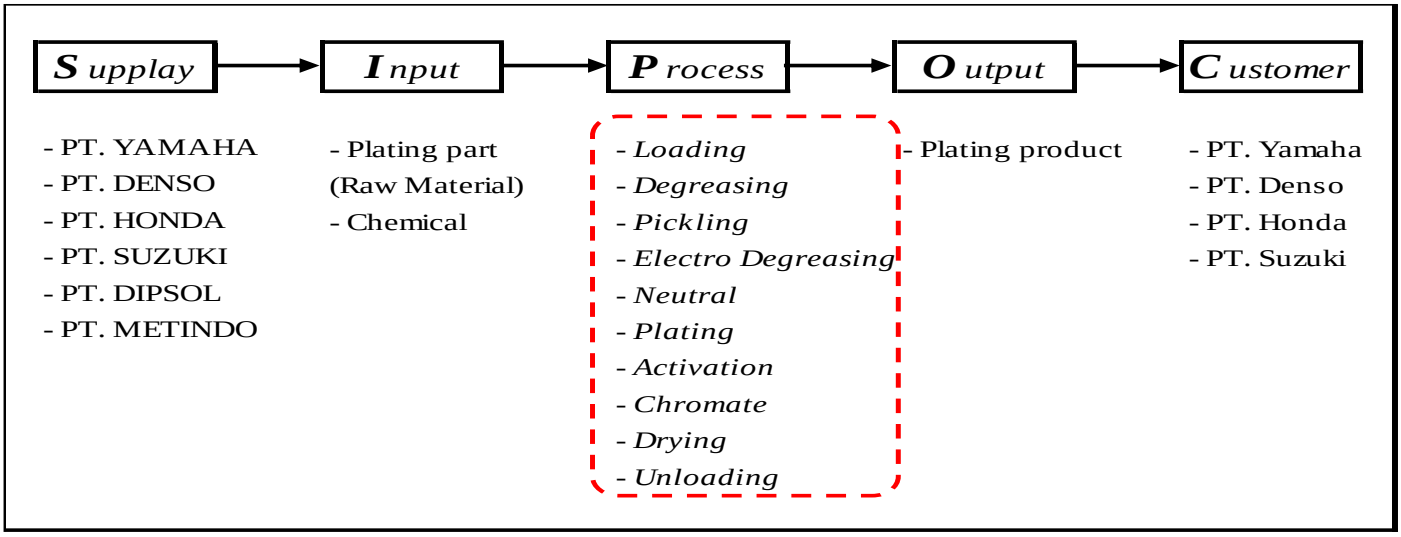
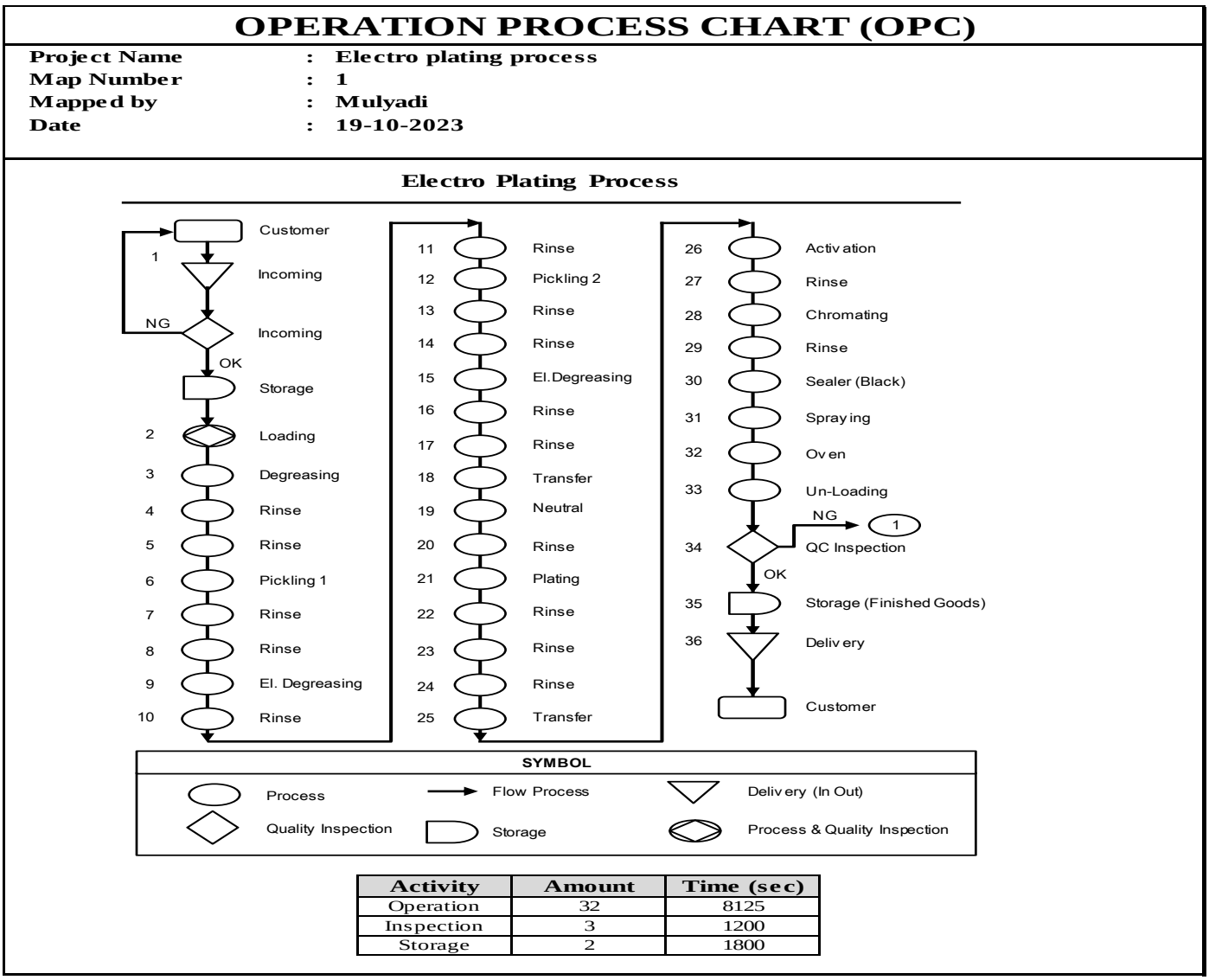


Fig 3 SIPOC Diagram

➢ *OPC (Operation Process Chart).*

The Operation Process Chart maps or describes the operation and inspection processes that occur at PT. Plating services from start to finished product.



Activity	Amount	Time (sec)
Operation	32	8125
Inspection	3	1200
Storage	2	1800

Fig 4 Operation Process Chart (OPC)

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➢ *CTQ (Critical to Quality).*

Critical to Quality (CTQ) in the six sigma methodology is used to improve product quality. CTQ refers to certain characteristics of a product that directly affect customer satisfaction or meet quality requirements. Identifying and understanding CTQs is a critical step in quality control and process improvement to ensure a product or service meets customer expectations. Types of CTQ on Electro Plating products at PT. Plating services are determined based on the type of critical reject. From the results of observations in the production section, CTQ is included, namely Opaque, PellOff, Fleck.

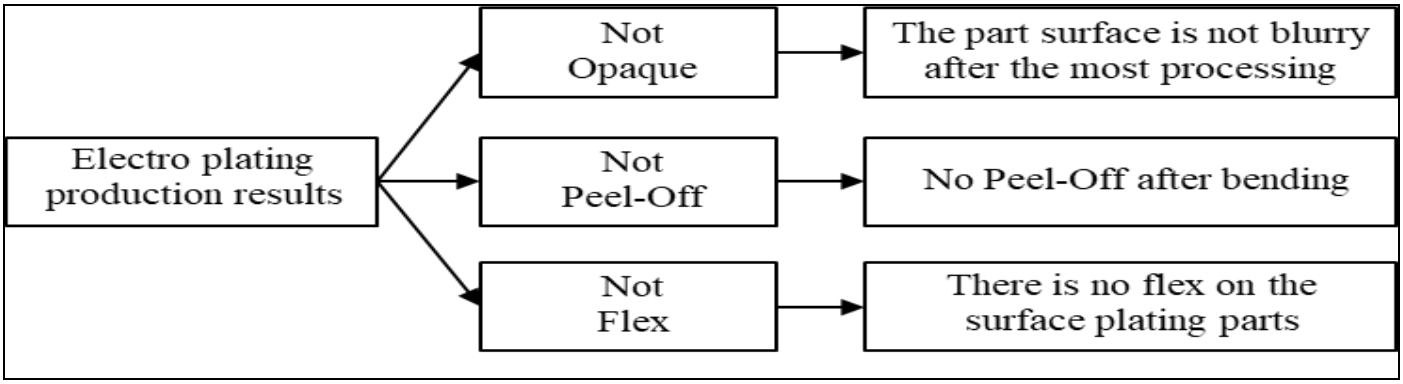

Fig 5 Crical to Quality CTQ

➢ *There are 3 Electro Plating Rejects at PT. Plating Services:*

- *Opaque*

Opaque by looking at the visual part in finished goods, the part looks dull/opaque and not shiny according to the specified standards. Opaqueness in the electro plating process occurs due to several factors, it could be because the raw material is dirty, the temperature of the plating solution is high, there are impurities in the plating solution, the concentration of the solution is not balanced, the washing during each process is not clean and so on.

- *Peel-Off*

Peel-Off in parts after plating is the occurrence of cracks resulting from plating if the part is bent or bent. Peel-Off can be caused by unstable current from the electro rectivier, oil mixed with the plating solution, washing parts in each process tank that is not clean.

- *Flex*

What is meant by spots is the presence of spots or flecks, both white and black, on the surface of the part after plating. Spots occur because the washing in each process tank is not clean, the concentration of the solution or the pH of the activation solution is high, the spray before entering drying is not clean or the compressor air is dirty due to dust or dirt from the dirty air filter.

B. Measure Stage

The measure stage here measures process performance at PT. Plating Services, this stage focuses on collecting relevant data to evaluate the extent to which the process meets quality requirements and identify potential problems.

➢ *DPMO and Sigma Level Calculation*

DPMO (Defect Per Million Opportunities) measures how often rejects or failures occur at PT. Plating Services to achieve a high quality level where the DPMO is getting closer to zero, the lower the DPMO number, the higher the process quality level. DPMO calculation at PT. Plating services are carried out from January-September 2023 with an average total production of 4,155,216 pcs and total defects of 79,518 pcs. The DPMO calculation result was 6.379 with a sigma level of 3.98 sigma.

Table 3 Average Reject Data Jan-Sept 2023

Production	Reject	% NG	Pcs/ loading	loading/ 2shift
4,155,216	79,518	1.91%	1,400	120

$$DPMO = \frac{\text{Total production defects}}{\text{Production quantity x probability of defect per unit}} \text{ x } 1{,}000{,}000$$

$$DPMO = \frac{79{,}518}{4{,}155{,}216 \text{ x } 3} \text{ x } 1{,}000{,}000$$

$$DPMO = 6{,}379$$

$$Sigma = 3{,}98$$

➢ *Control p Chart*

A control chart is a statistical tool used to determine whether a process is under control or not. The control chart used is the p control chart because the data processed is data on the number of rejects and the number of production varies. The following is the p control chart calculation table:

$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} \qquad CL = \bar{p}\,\frac{\sum np}{N} \text{ x } 100\%$$

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

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Table 4 Proportion of Reject Products Jan-Sep 2023

Observation	The number of samples	The number of rejected products	Proportion of rejected products	UCL	CL	LCL
1	4,540,620	94,564	0.021	0.0193	0.0191	0.0189
2	4,029,900	86,178	0.021	0.0193	0.0191	0.0189
3	4,518,010	90,347	0.020	0.0193	0.0191	0.0189
4	2,433,900	45,042	0.019	0.0193	0.0191	0.0189
5	4,214,770	100,059	0.024	0.0193	0.0191	0.0189
6	4,333,140	51,231	0.012	0.0193	0.0191	0.0189
7	4,311,860	64,745	0.015	0.0193	0.0191	0.0189
8	4,540,620	94,299	0.021	0.0193	0.0191	0.0189
9	4,474,120	89,201	0.020	0.0193	0.0191	0.0189
Amount	**37,396,940**	**715,666**	**0.019**			
Avg	**4,155,216**	**79,518**				
Stdev	**667,904**					
σ/p	**0.019**					
1-p	**0.981**					

➢ *Control Chart p, Rejected Products can be Seen in the Graphic Image as Follows:*

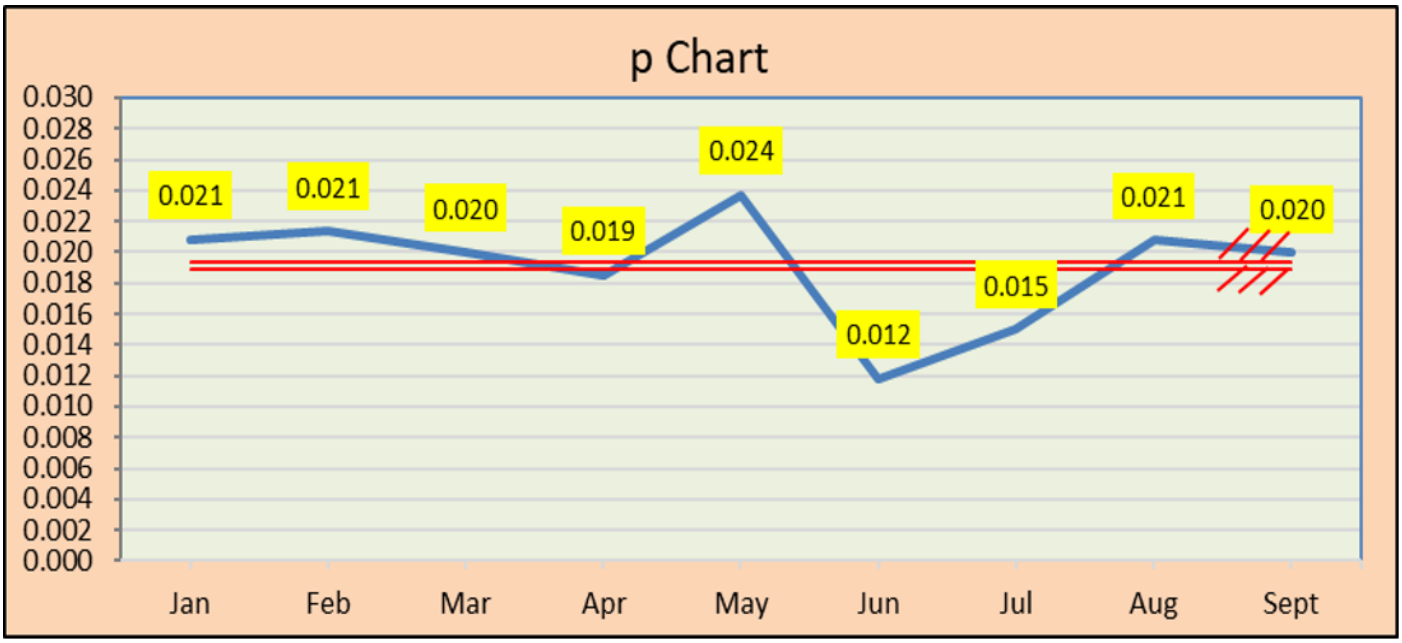

Fig 6 p Chart Graphic Jan-Sep 2023

Analysis of the p-control chart for electro plating products above shows that the distribution of product rejects is outside the upper and lower control limits. This abnormality occurs because product rejects often occur.

C. Analysis Stage

The analysis stage is understanding and analyzing the basic causes of problems in the electro plating process at PT. Plating Services. This stage is an important step in finding effective solutions to improve the quality and performance of the electroplating process.

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Table 5 Root Cause of Rejection Opaque, Peel-off and Flex

No	Process Name	Process Type	Potential Reject	Cause Reject	Factor
1	Loading material	Loading material into the barrel	The material still has dirt/oil attached to it	The material is put into the barrel so that the oil has not drained	Material
2	Degreasing	Removes dirt and oil in the material	Oil sticks to unclean material	Dirt and oil are not removed because the solution concentration is not perfect	Method
3	Rinsing	Flow rinsing	Water flow is less/not flowing optimally	Rinsing water cannot rinse because the flow is not large enough	Machine
				Oil that is still stuck to the material is not clean	Material
4	Pickling	Cleaning material from rust	Material is still dirty	Solution concentration is not standard	Method
5	Rinsing	Flow rinsing	Water flow is less/not flowing optimally	Rinsing water cannot rinse because the flow is not large enough	Method
6	Electro Degreasing	Cleans dirt that is difficult to remove	Unstable electric current	The electric current does not flow stably because the V-Block electrical conductor is dirty	Machine
7	Rinsing	Flow rinsing	Water flow is less/not flowing optimally	Rinsing water cannot rinse because the flow is not large enough	Method
8	Neutralisation	Neutralizes the surface of the material	Not clean enough	Solution concentration is not standard	Method
9	Rinsing	Rinsing	The pH of the rinse water is low	The neutral rinsing water supply of water from after plating has less flow and low pH	Method
10	Plating	Plating process	Not exposed to plating	Current does not reach target	Machine
				The concentration of the solution is not standard	Method
				Non-standard barrels	Machine
			The plating layer is uneven	Unstable current	Machine
			Non-standard coating	The electrolyte solution does not react	Machine
			Blister	Unstable current	Machine
			The plating layer is too thick or thin	Plating time is not standard	Machine
				The anode does not react	Machine
			Color	High impurities	Machine
			The product surface is burned	Electric current too high	Machine
11	Rinsing	Rinsing with demin water	Dirty water	The flushing water turns acidic	Method
				High water conductivity	Machine
				Rinsing water is crusty and dirty	Machine
12	Activasi	Pembersihan permukaan produk after plating	Kurang bersih	Processing time is not up to standard	Machine
				The pH of the solution is high	Machine
13	Rinsing	Flow rinsing	Water flow is less/not flowing optimally	Rinsing water cannot rinse because the flow is not large enough	Method
14	Drying	Drying the product after plating	Discoloration	The product is still wet because the drying is not dry enough	Method
				There is contamination originating from the air around the production area that sticks to the product	Environment

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Table 6 Why, why Analysis

4 M	Why 1	Why 2	Why 3	Why 4	Why 5	Solusi
Opaque						
Material	Material dirty with oil	The customer's process must use oil	The stamping process must use lubricating oil	Lack of oil will cause scratches		The oil is drained before the material enters loading
Method	Dirty rinse water	Small flow rinsing	There are no water flow standards yet			Standards for opening the valve are made so that the water flow flows perfectly, the oil above the water surface will come out through the over flow properly
	Impurities	The material carries oil dirt and other impurities into the solution	Oil mix material from customer	The stamping process must use lubricating oil	Without lubricant, the material will scratch	Check impurities every day and process carbon in the plating solution if impurities exceed standards
Machine	Unstable power supply	Dirty current-conducting V-Block	Cleaning is not clean	V-Blok cleaning controls are not routinely carried out	Operator awareness is still lacking	Retraining was carried out on the importance of daily maintenance for good quality production results
	The temperature of the plating solution is high	Problem with solution cooling chiller	The solution cooling chiller has a small capacity	As capacity usage decreases		Increase chiller capacity
Man	Lack of control	Operator awareness is lacking				Re-training of employees was carried out

4 M	Why 1	Why 2	Why 3	Why 4	Why 5	Solusi
Peel-Off						
Material	Material dirty with oil	The customer's process must use oil	The stamping process must use lubricating oil	Lack of oil will cause scratches		The oil is drained before the material enters loading
Method	Dirty rinse water	Small flow rinsing	There are no water flow standards yet			Standards for opening the valve are made so that the water flow flows perfectly, the oil above the water surface will come out through the over flow properly
	Impurities	The material carries oil dirt and other impurities into the solution	Oil mix material from customer	The stamping process must use lubricating oil	Without lubricant, the material will scratch	Check impurities every day and process carbon in the plating solution if impurities exceed standards
Machine	The plating layer is uneven	The rectifier current is unstable	Induction rectivier cables and connections	Maintenance rectivier kurang		Rectivier maintenance is lacking
	There is oil content in the plating solution	Oil is still carried into the process	No draining was doneoli			The oil is drained before the material enters the loading process
	There are impurities in the plating solution	Carried away by other impurity materials and components				Check impurities every day and process carbon in the plating solution if impurities exceed standards
Man	Lack of control	Operator awareness is lacking				Re-training of employees was carried out

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4 M	Why 1	Why 2	Why 3	Why 4	Why 5	Solusi
Flex						
Material	Material dirty with oil	The customer's process must use oil	The stamping process must use lubricating oil	Lack of oil will cause scratches		The oil is drained before the material enters loading
Method	Dirty rinse water	Small flow rinsing	There are no water flow standards yet			Standards for opening the valve are made so that the water flow flows perfectly, the oil above the water surface will come out through the over flow properly
	High activation pH	As production progresses, the pH will rise	pH meter is inaccurate. pH meter calibration is carried out once a week			Perform pH calibration every day
Machine	Low blow water pressure	The air connection pipe is leaking	Worn air pipe			Control of wind connection pipes early morning shift
	Dirty blow air	Dirty airblow filter	Filter clogged	Airblow filter control is rarely performed		Carry out airblow filter control every morning at the start of the shift
	The temperature of the plating solution is high	Problem with solution cooling chiller	The solution cooling chiller has a small capacity	As capacity usage decreases		Increase chiller capacity
	There are impurities in the plating solution	Carried away by other impurity materials and components				Check impurities every day and process carbon in the plating solution if impurities exceed standards
Man	Lack of control	Operator awareness is lacking				Re-training of employees was carried out

➢ *Identify the Root Cause of the Problem*

Identification of the root causes of problems is the process of identifying the factors that underlie or contribute most to the emergence of problems or rejects in the electro plating process at PT. Plating Services. Understand the real cause of the problem, not just the symptoms or effects. The use of the Fishbone diagram is based on the CTQ obtained from the results of analysis and brainstorming with the company.

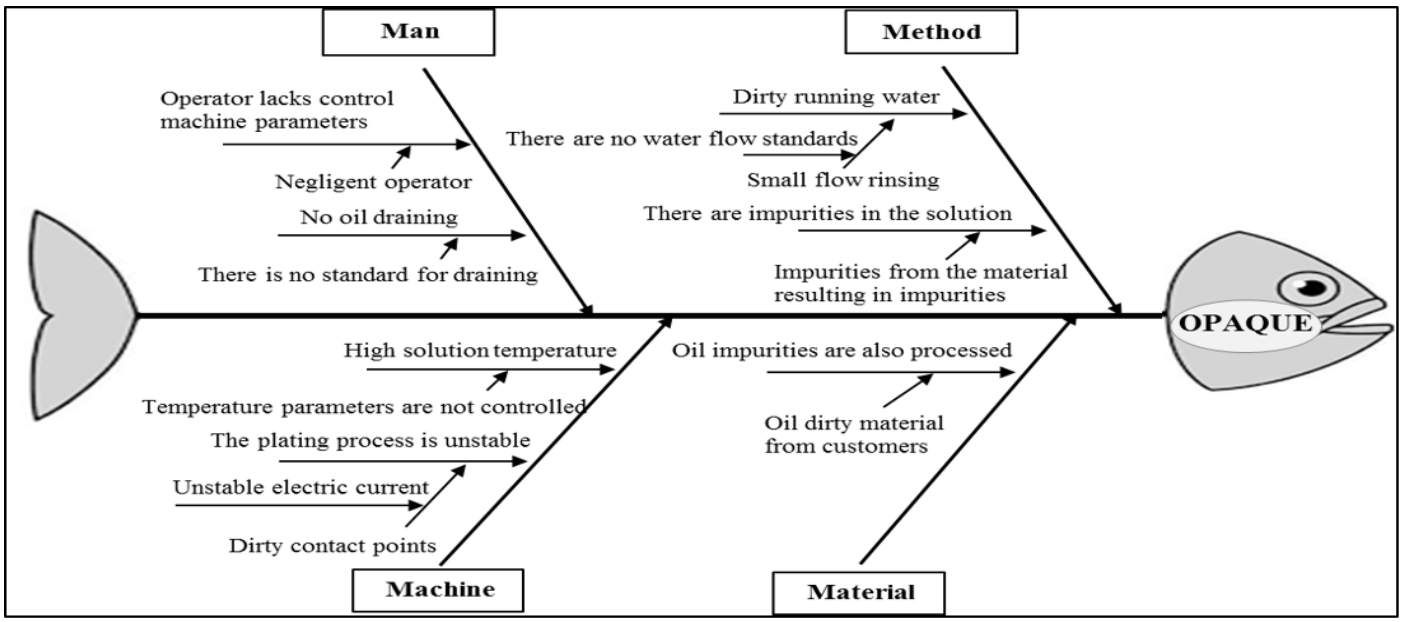

Fig 7 Opaque Fishbone Diagram

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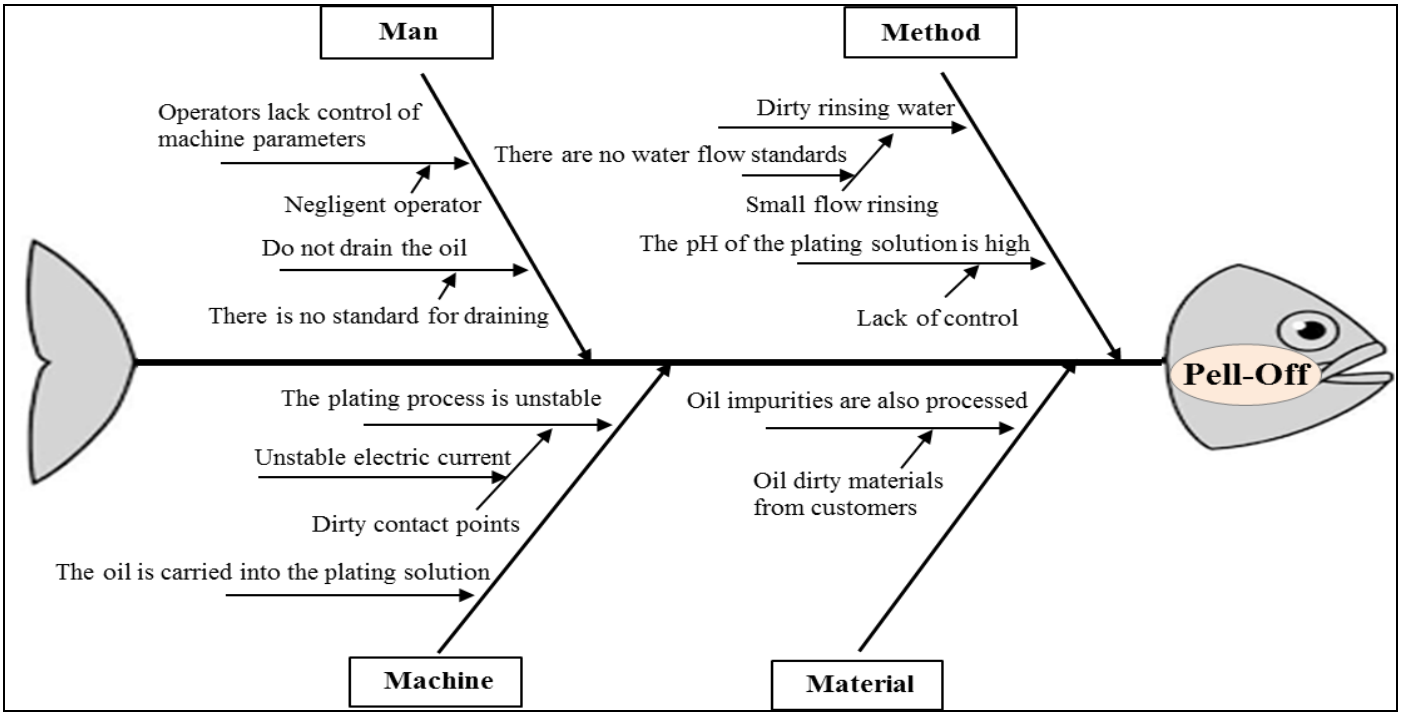

Fig 8 Peel-Off Fishbone Diagram

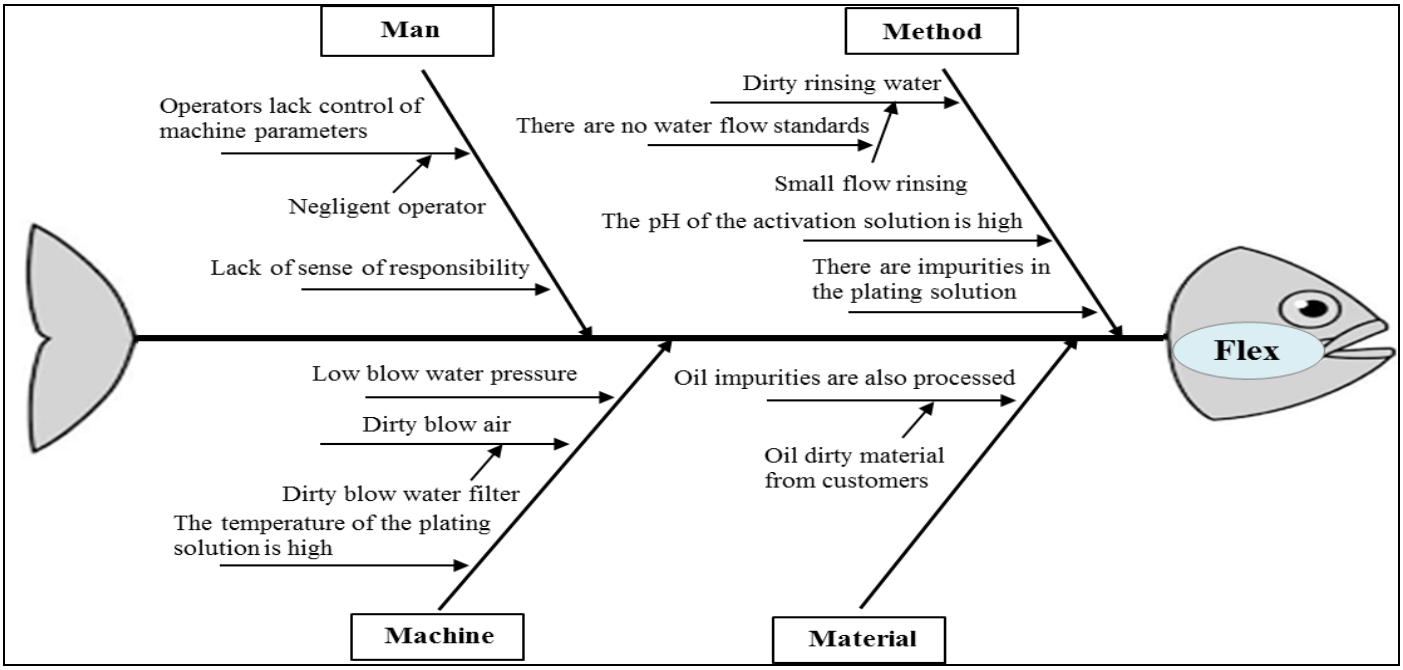

Fig 9 Flex Fishbone Diagram

In this analysis stage, control data for the solution, temperature of the solution, etc. that is currently running (Current Condition) is carried out and written on the checksheet with the important reference being that it falls within a predetermined range, there is data on the results of the analysis of the solution, temperature and others in the range position. down to the center line. Thus, after the production process takes place, the risk of reducing the concentration of the solution to the lower specification limit is very high. In this way, the quality of the production results is not optimal and results in high rejects.

D. Improvement Stage

Improvement is an important step in the Six Sigma program, especially in finding alternative solutions to problems that occur which result in production rejects. As a corrective step towards the causes of damage, this can be done by compiling a list in the form of a 5W1H table consisting of What, Why, When, Who, Where and How. Each type of reject requires different treatment so that handling production rejects is more focused and directed. Due to the high level of damage that causes Blurryness, Peel-Off and Spots, as an anticipatory step, the following corrective action plan can be implemented:

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Table 7 5W + 1H

TYPE	5W + 1H	DESCRIPTION OF REPAIR PLAN
The main purpose	What	Reduces rejects resulting from the electro plating process
Reasons for Use	Why	So that the results of the electro plating production process produce good products without rejects and according to specifications
Location	Where	Carried out at the company PT. Plating Services
Implementation	When	Due for production in October 2023
Man	Who	Responsibilities of the author, Production Manager, Quality Manager, Maintenance Manager
Method	How	Using the Six Sigma DMAIC method

On September 30 2023, the response to the reject problem was carried out by carrying out total maintenance, thorough cleaning, large carbon in the plating solution, cleaning all rinsing tanks, and everything related to the impact of reject problems. At the beginning of October 2023, data collection and analysis will begin for 1 month. The following is data on before and after blurry rejection, peel-off and spots:

Table 8. Before Improvement Sept '23

Production	Reject	% NG	Pcs/ loading	loading/ 2shift
4.474.120	89.202	1,99%	1.400	120

$$DPMO = \frac{89,202}{4,474,120 \times 3} \times 1,000,000$$

DPMO = 6,646

Sigma = 3,98

Table 9 After Improvement Oct 2023

Production	Reject	% NG	Pcs/ loading	loading/ 2shift
4.539.640	38.011	0,84%	1.400	120

$$DPMO = \frac{38,011}{4,539,640 \times 3} \times 1,000,000$$

DPMO = 2,791

Sigma = 4,27

Table 10 Before Improvement 2023

Reject type	Qty	%	% Cummulative
Opaque	36,296	41%	41%
Peel Off	30,488	34%	75%
Flex	22,417	25%	100%

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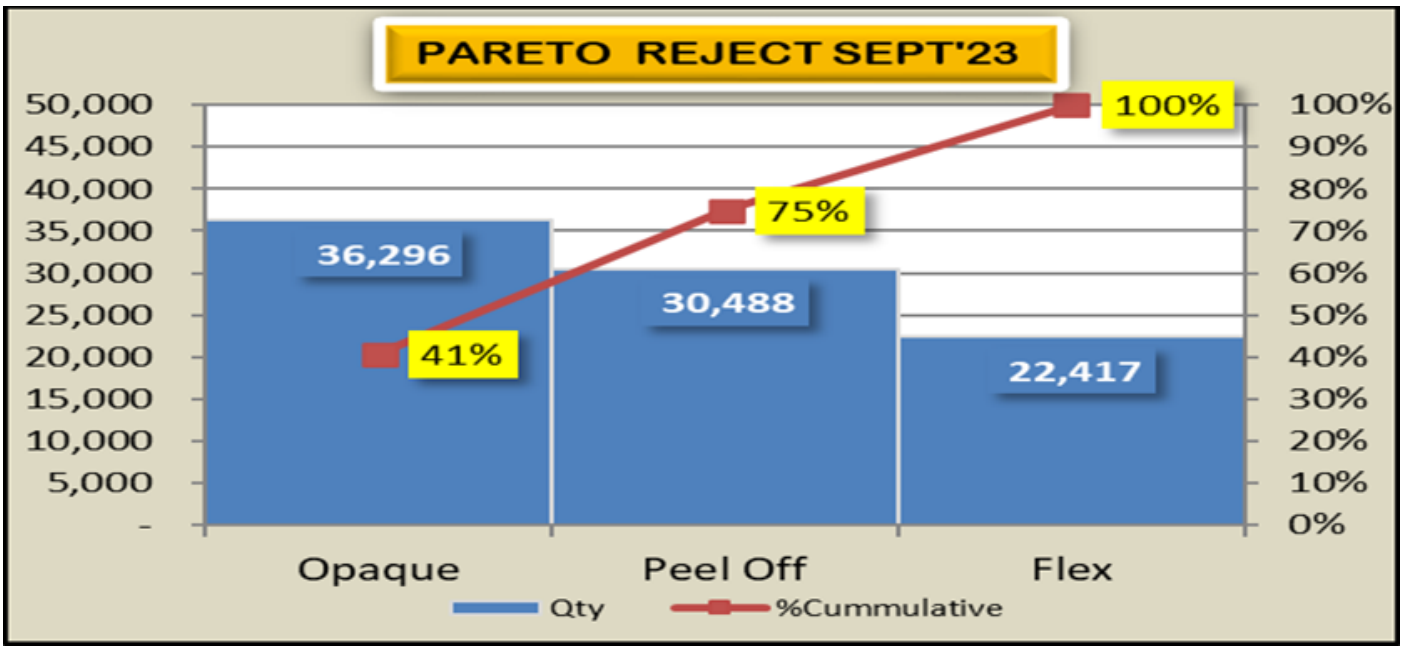

Fig 10 Pareto Before Improvement September 2023

Table 11 After Improvement 2023

Reject type	Qty	%	% Cummulative
Opaque	8,379	38%	38%
Peel Off	7,565	34%	72%
Flex	6,123	28%	100%

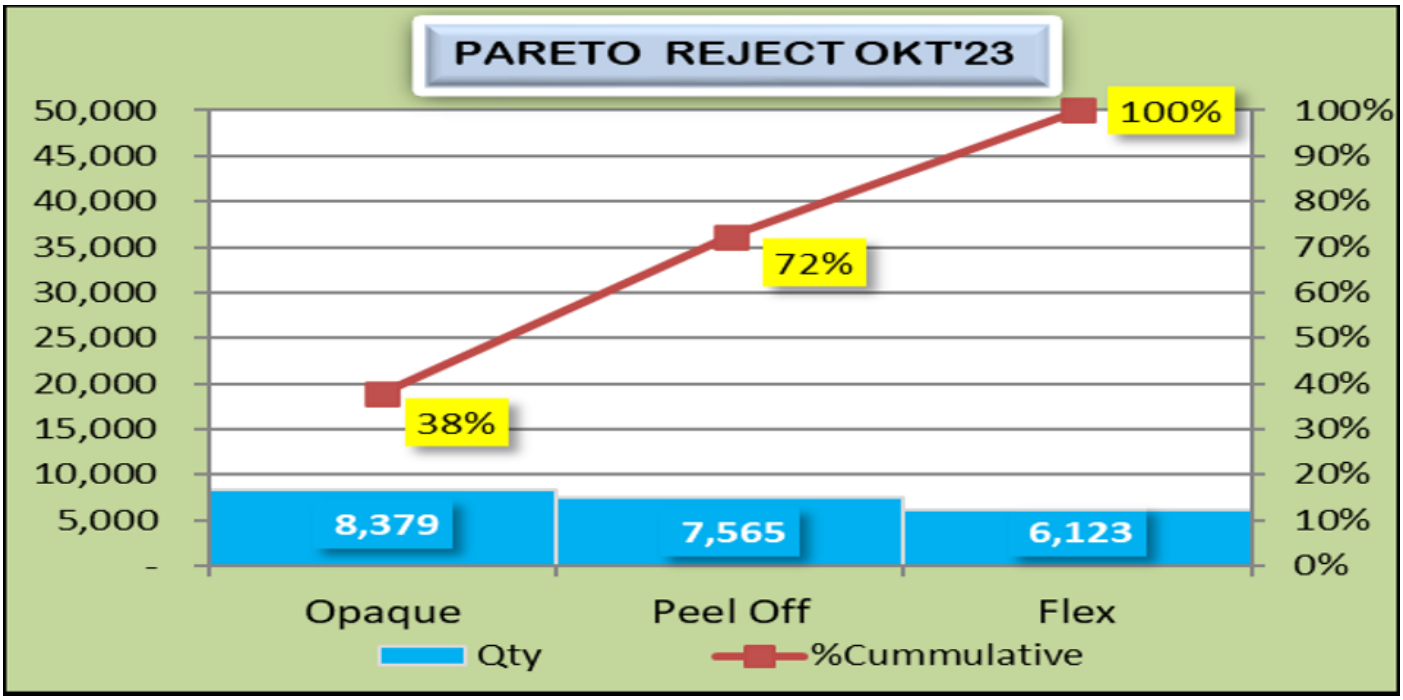

Fig 11 Pareto After Improvement October 2023

Table 12 Data Reject before Improvement Sept 2023

Production	Good	Opaque	Peel-Off	Flex	Not Good	%NG	DPMO	Sigma	Working days
4.474.120	4.384.919	36.296	30.488	22.417	89.201	1,99%	6.646	3,98	26

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Table 13 Data Reject after Improvement Oct 2023

Production	Good	Opaque	Peel-Off	Flex	Not Good	%NG	DPMO	Sigma	Working days
4.539.640	4.501.629	22.067	8.379	7.565	38.011	0,84%	2.791	4,28	26

- *Control p Chart before and after Improvement :*

Table 14 Data for September 2023

Observation	The number of samples	The number of rejected products	Proportion of rejected products	UCL	CL	LCL
1	162260	3044	0,019	0,0209	0,020	0,0189
2	140980	3112	0,022	0,0209	0,020	0,0189
3	184870	3537	0,019	0,0209	0,020	0,0189
4	184870	3866	0,021	0,0209	0,020	0,0189
5	184870	3478	0,019	0,0209	0,020	0,0189
6	184870	3441	0,019	0,0209	0,020	0,0189
7	162260	3189	0,020	0,0209	0,020	0,0189
8	140980	3077	0,022	0,0209	0,020	0,0189
9	184870	3856	0,021	0,0209	0,020	0,0189
10	184870	3618	0,020	0,0209	0,020	0,0189
11	184870	4032	0,022	0,0209	0,020	0,0189
12	184870	3518	0,019	0,0209	0,020	0,0189
13	162260	3201	0,020	0,0209	0,020	0,0189
14	140980	3056	0,022	0,0209	0,020	0,0189
15	184870	3759	0,020	0,0209	0,020	0,0189
16	184870	3399	0,018	0,0209	0,020	0,0189
17	184870	3774	0,020	0,0209	0,020	0,0189
18	184870	3598	0,019	0,0209	0,020	0,0189
19	162260	3310	0,020	0,0209	0,020	0,0189
20	140980	3102	0,022	0,0209	0,020	0,0189
21	184870	3227	0,017	0,0209	0,020	0,0189
22	184870	3471	0,019	0,0209	0,020	0,0189
23	184870	3846	0,021	0,0209	0,020	0,0189
24	184870	3345	0,018	0,0209	0,020	0,0189
25	162260	3225	0,020	0,0209	0,020	0,0189
26	140980	3121	0,022	0,0209	0,020	0,0189
JUMLAH	4474120	89202	**0,020**			
Avg	**172.082**	**3.431**	0,181			
Stdev	**17.816**					
σ/p	**0,020**					
1-p	**0,980**					

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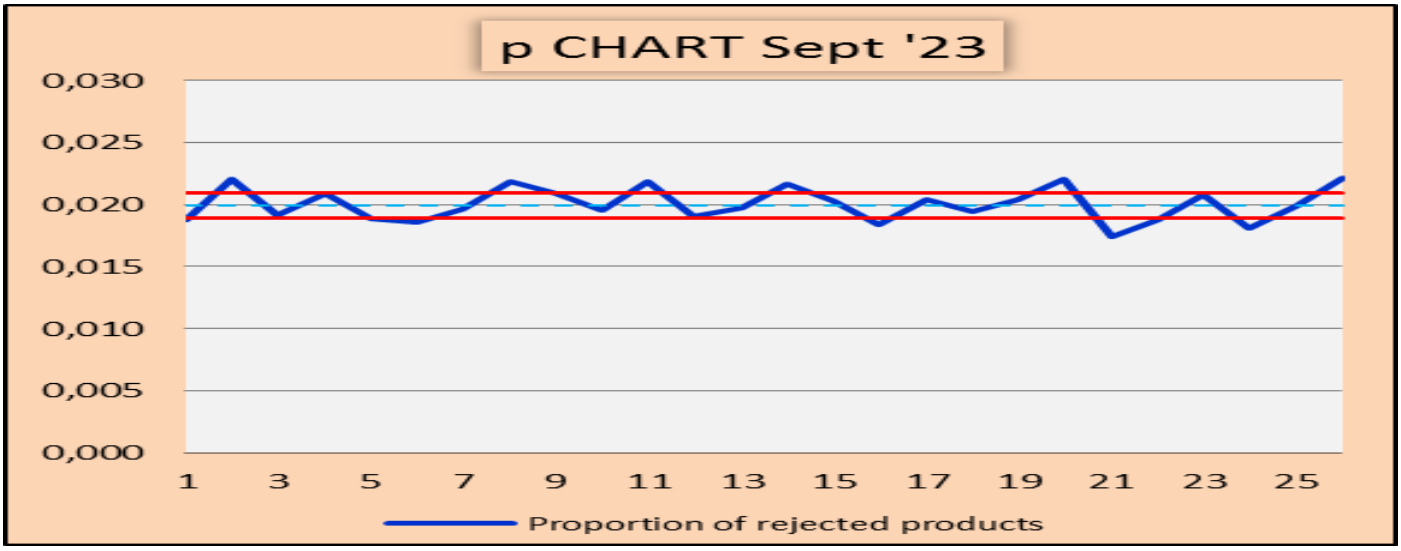

Fig 12 p Chart Graph September 2023

Table 15 Data for October 2023

Observation	The number of samples	The number of rejected products	Proportion of rejected products	UCL	CL	LCL
1	184870	1533	0,008	0,0054	0,005	0,0044
2	184870	1267	0,007	0,0054	0,005	0,0044
3	184870	1056	0,006	0,0054	0,005	0,0044
4	184870	1091	0,006	0,0054	0,005	0,0044
5	162260	957	0,006	0,0054	0,005	0,0044
6	140980	912	0,006	0,0054	0,005	0,0044
7	184870	934	0,005	0,0054	0,005	0,0044
8	184870	987	0,005	0,0054	0,005	0,0044
9	184870	955	0,005	0,0054	0,005	0,0044
10	184870	845	0,005	0,0054	0,005	0,0044
11	162260	821	0,005	0,0054	0,005	0,0044
12	140980	834	0,006	0,0054	0,005	0,0044
13	184870	894	0,005	0,0054	0,005	0,0044
14	184870	785	0,004	0,0054	0,005	0,0044
15	184870	739	0,004	0,0054	0,005	0,0044
16	184870	802	0,004	0,0054	0,005	0,0044
17	162260	644	0,004	0,0054	0,005	0,0044
18	140980	609	0,004	0,0054	0,005	0,0044
19	184870	764	0,004	0,0054	0,005	0,0044
20	184870	728	0,004	0,0054	0,005	0,0044
21	184870	697	0,004	0,0054	0,005	0,0044
22	184870	705	0,004	0,0054	0,005	0,0044
23	162260	607	0,004	0,0054	0,005	0,0044
24	140000	545	0,004	0,0054	0,005	0,0044
25	184870	698	0,004	0,0054	0,005	0,0044
26	184870	658	0,004	0,0054	0,005	0,0044
JUMLAH	**4.539.640**	**22.067**	**0,005**			
Avg	**177.481**	**1.077**	0,055			
Stdev	**16.847**					
σ/p	**0,005**					
1-p	**0,995**					

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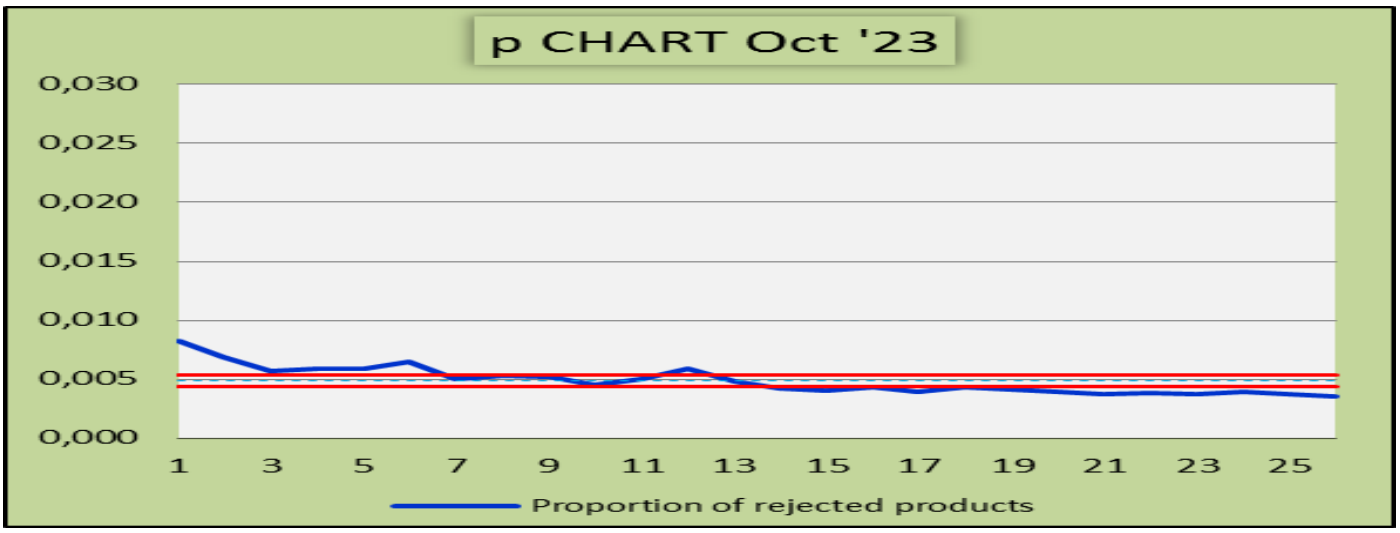

Fig 13 p Chart graph October 2023

Judging from the comparison of the results before and after improvement, there is a significant difference, the value of the proportion of defects from the previous month of September 2023 was 0.020 to 0.005 in October 2023, variations in data distribution also occurred in September 2023, high and low, while in October 2023 it tended to average variation. There are changes that are improving even though they still need better improvements.

E. Control Stage

This stage is an important step in creating a continuous improvement process towards achieving zero reject conditions. Improving production quality is not a one-day work process, but rather is a process that needs to be constantly monitored and supervised so that the targets that have been set can be achieved, especially in efforts to achieve the highest level of quality achievement through efforts to emphasize factors that can cause product rejects or errors during the production process.

Several tools that can be applied as control mechanisms for various processes that can cause rejects and procedural errors can be described in the monitoring checksheet and X-R Chart.

The previous plating solution concentration control did not use graphs and the analysis results were fixed in the standard range and did not matter about the position of the analysis value below or above the standard. In October 2023, a control analysis of the solution was carried out using an X-R Chart, the concentration range was increased and the UCL, LCL were controlled and the data spread was narrowed.

V. CONCLUSION

From the results of research conducted at PT. Plating Services, it can be concluded several things as follows: Overcoming the problem of blurred rejects, peel-offs and spots on electroplating products requires a systematic approach to identify the main causes and take appropriate corrective steps by implementing the Six Sigma method to collect and analyze data related to the electroplating process. Identify variances and variations in the process that can contribute to blurry rejects, peel-off, and spots. With Six Sigma DMAIC, 5W and Fishbone diagrams can be an effective solution to improve product quality well.

Factors causing high levels of blurring, peel-off and spots are : Under- or over-cleaning of the metal surface before the electroplating process can cause problems such as peel-off. Make sure the cleaning process is carried out correctly and according to standards. Contamination of the electroplating solution by foreign materials/impurities can cause blurring and spots on the final layer. Make sure the quality of the chemicals and water used in the process is not contaminated with other impurities. Machinery or equipment that is not properly calibrated, or experiences wear and tear, can produce products that do not meet standards. Make sure all equipment functions well and is regularly maintained. Variations in temperature, time, or electric current in the electroplating process can produce inconsistent layers. Careful monitoring and control of process parameters to ensure process stability.

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