Reducing Coating Defects by Implementing Auto Dripping System on The Finishing Machine

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Abstract— **Finishing Process is one of the most important processes in the manufacture of resistors, because it is the process of forming the resistor body by coating the resistor with a coating liquid. However, in this process there are still many cases of product defects, one of the main causes is the uncontrolled viscosity of the coating liquid causing the formation of body resistors is not good, or what is called Body deform and body thin defects. Auto Dripping is a useful tool for automatically dripping methanol liquid which aims to control the viscosity of the coating liquid in the finishing process. Because Auto Dripping is a tool that has just been implemented and does not yet have the right parameter settings, it is necessary to do trials to find the right parameters so that Auto Dripping functions properly. In Auto Dripping there are two settings that can be controlled, namely Stroke Speed and Stroke Length, these two settings affect the output of methanol liquid that comes out. In this study using SPC tools to analyze the parameters being tested, namely the Control Chart which is used to monitor the stability of a process and study process changes from time to time. then, in this study also used the Process Capability Analysis method. This method is very effective in viewing the performance of a process, is used to measure process capability by comparing its distribution with the distribution of specifications accurately and provides a clearer picture. After carrying out this project, the authors concluded that the implementation of the Auto Dripping set up parameter has proven to be quite influential in reducing the case of coating defects caused by uncontrolled viscosity, namely by maintaining the stability of the coating viscosity so that it can produce resistors that meet specifications. From the data above, the production of resistors has been running stably with a period of 5 weeks, with 100 resistor samples being measured. With an average value of 2.82 mm. As for the Cpk value after implementing the new parameter setup, which is 3.35, this is a high result and meets the standard, which is ≥1.5.**

Keywords: Auto Dripping, Capability Analysis, Control Charts

I. INTRODUCTION

QUALITY is a characteristic of a product or service that has been determined by the customer and is obtained through continuous improvement. The advantages that will be achieved by companies with quality products are cost savings. Increased product quality will reduce production costs, product defects will certainly result in rework, which requires additional material costs, machine updates, which reduce company profits [1]. Companies that produce goods and services without paying attention to quality are the same as eliminating expectations the life support of the company. In other words, product quality or services produced by the company is a major key in winning and maintaining competition in the market [2].

Product Defects are a big problem in the manufacturing process, especially in high volume production. Due to the frequent occurrence of defects in a manufacturer's production will reduce the productivity of a company. The definition of defect products according to [3] is if it is dangerous because it fails to perform in a manner reasonably expected in light of its nature and intended function. The defect product can still be repaired but it costs more to fix it. Meanwhile, according to [4] number of defects is a simple way to determine the quality of a product. Quality of a process can also be determined on the basis of number of defects being produced by the process.

In this research, a product is always related to product defects, for example in the resistor finishing process, there are many cases of defects that often hinder the production of resistors. Normally, the production of resistors in a week is 180,000 pcs. Meanwhile, during the research, a large number of resistors that are found defective in the finishing process. These conditions had reduced the production of resistors which was originally 180,000 pcs to less than 170,000 pcs per week. One of the main causes is the uncontrolled viscosity of the coating liquid. The coating liquid that is too thick can produce a defective resistor which is called Body Deform. Also, when the coating liquid is too diluted can produce a defective resistor called Body Thin. Therefore, it is important to maintain the viscosity of the coating liquid. In this research we add liquid methanol to the coating liquid, which is useful for slowing down the coating liquid to thicken.

At the beginning, the application of adding methanol liquid to the coating liquid was done manually by an operator. When the operator is on duty, He will add methanol liquid by pouring methanol into the coating liquid only if the operator thinks the coating liquid is too thick. The problem is manual application was considered not effective to control the liquid's viscosity.

Therefore, the company developed an idea to make a tool that can drip methanol liquid automatically using an Electromagnetic metering pump. This tool is called Auto Dripping. And this tool is expected to maintain the viscosity of the coating liquid during the production process. Because there is no data that can conclude whether Auto Dripping can control the administration of methanol and can maintain the viscosity of the coating liquid the authors try to analyze this experiment which entitled "Reducing Coating Defects by Implementing Auto Dripping System on The Finishing Machine".

II. METHOD

The research method used for reducing coating defects consists of two methods, Process Capability Analysis (PCA) and Statistical Process Control (SPC).

A. Process Capability Analysis (PCA)

PCA involves merging statistical tools derived from the normal curve and control charts with sound engineering judgment to interpret and scrutinize data portraying a process. Its objective is to gauge the breadth of variation and assess how time impacts both the mean and the spread. Incorporating the administration, analysis, and implementation of process capability studies is crucial within the realm of quality engineering.

The outcomes of such analyses can be applied in new design implementations, devising inspection strategies, and refining evaluation methodologies. This methodology serves as a mechanism to preempt defects during production cycles by leveraging superior designs, leveraging precise comprehension of machine or process limitations, and discerning process variables that are controllable or beyond control. [5].

The process capability analysis is defined as the engineering study to estimate the process capability. The process capability measures the process ability to meet the specification requirements of a quality characteristic. The process capability analysis is an essential part of an integral program of quality improvement. The graph used for process capability analysis is shown in Figure 1.

In Figure 1, process capability analysis is widely used in the industry. Process capability analysis allows us to observe the specification limits: the lower specification limit (LSL) and the upper specification limit (USL). Therefore, it is possible to isualize the average μ that represents the process central tendency, and the nominal value τ is the nominal value or target [6].

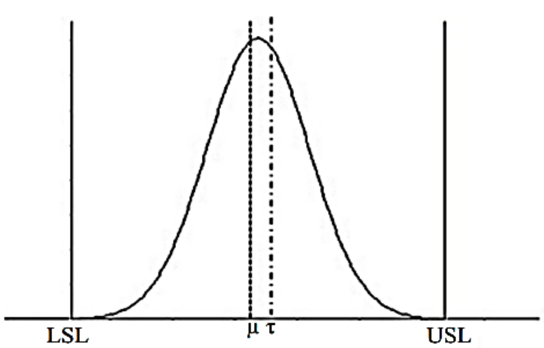

Fig. 1. Process capability analysis graph

1. Process Capability (Cp)

The potential process capability index (Cp) compares the specification variations allowed for the process with the amplitude of the real variation of it which comes from dividing the width by the amplitude of the process natural variation [6]. This concept straightforwardly links Process Capability to the Specification Range without addressing the process's positioning concerning the specifications. When the Cp values >1.33, it signifies that the process sufficiently aligns with the specifications. Cp values ranging between 1.33-1.00 suggest that the process is capable of meeting the specifications but necessitates meticulous control. If Cp values fall <1.00, it indicates that the process lacks the capability to meet the specifications. When the process is centered within the specifications and exhibits an approximately "normal" distribution, Cp=1.00, resulting in a nonconforming fraction of 0.27%. This fraction is also termed as process potential.

2. Procces Capability Index (Cpk)

The real process capacity index can be seen as an adjustment to the index Cp to consider the process centering. The Cpk magnitude concerning Cp is a direct measurement of how far from the center the process is operating. Equation which shown in Figure 3, is used for its calculation, in which μ represents the process average, σ the standard deviation and USL and LSL lower and upper specifications respectively.

CPK is very useful and very widely used. Generally, a CPK greater than 1.33 indicates that a process is capable in the short term. Values less than 1.33 indicate that the variation is too wide compared to the specification.

TABLE I
CP VALUES AND THEIR INTERPRETATIONS [7]

Index Value (Cp)	Class or Process Category	Decisions (if the process are centered)
Cp 2.2	World class	It has six sigma quality
Cp > 1.33	1	Adequate
1 < Cp <1.33	2	Partially adequate, requires a strict control.
0.67 < Cp < 1	3	Not adequate for the job. A process analysis is necessary. Requires serious modifications to reach a satisfactory quality
Cp < 0.67	4	Not adequate for the job. Require It has six sigma quality

B. Statistical Process Control (SPC)

Statistical Processing 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 actions while a product or service is being produced.

TABLE II
CP VALUES AND THEIR INTERPRETATIONS

Index Value (Cp)	Class or Process Category	Decisions (if the process are centered)
Cpk > 1.33	1	Adequate
1 < Cpk <1.33	2	Partially adequate, requires a strict control.
Cpk < 1.33	3	Not adequate for the job. A process analysis is necessary. Requires serious modifications to reach a satisfactory quality

Another definition of Statistical Process Control according to Vincent's opinion Gasperz is a terminology that has been used since 1970s to describe the use of statistical techniques in monitor and improve the performance of the process to produce products that are quality.

In general, SPC is a statistical technique that is widely used by companies or organizations to ensure that a process meets standards to produce a quality product. There are 7 main statistical tools can be used as a tool to control quality, some of them are:

1. Control Charts

A control chart is a graphical tool used to evaluate and monitor whether a process is under statistical quality control or not so that it can solve problems and produce quality improvements. The control chart shows changes in data from time to time but does not show the cause of a deviation even though the deviation will be visible on the control chart.

2. Check Sheets

Check sheets are tools for collecting data. They are designed specifically to the type of data to be collected. Check sheets aid in systematic collection of data. Some examples of check sheets are daily maintenance check sheets, attendance records, production logbooks, etc. [8].

3. Flow chart

A graphical representation of a process or the step-by-step solution of a problem, using suitably annotated geometric figures connected by flowlines for the purpose of designing or documenting a process or program.

C. Measurement Tool

1) Viscotester

Viscotester is a measurement tool used to measure the viscosity of a liquid. In this project, this tool is used to measure the viscosity of the coating liquid [9]. As for how to operate the Viscotester Rion VT 04F tool:

a. Prepare a cup to fill the liquid sample
b. Take a sample of the coating liquid with a cup to measure its viscosity
c. Fill the cup with coating liquid until it is almost full
d. Then take it to the laboratory to be measured
e. Then put the cup right under the rotor of the viscotester
f. Align the position of the rotor until it fits at the center point of the cup
g. Then insert the rotor into the cup according to the mark on the rotor
h. Turn on the viscometer
i. Let the viscotester turn on until it shows precise measurement results
j. After the measurement, turn off the viscotester.

2) Digital Thickness Gauge

Digital Thickness Gauge offers a fast and efficient way of checking thickness with a comfortable grip handle, thumb trigger and spring-loaded spindle with measurements shown on an easy-to-read LCD display. In this project, a thickness gauge is used to measure the body dimension of the sample resistor. As for how to operate the Digital thickness gauge:

a. Prepare a sample resistor to be measured
b. Press the on/off button on the device
c. Pay attention to the initial measurement value on the monitor, the initial measurement value must start from 0
d. If the initial value is not 0, then the device must be reset first
e. To reset press the origin button on the tool
f. Then place the sample resistor onto the round pointed tip of the tool
g. Navigate the round pointed tip to the center portion of the body resistor
h. Then record the measurement results on the monitor
i. Compare the measurement values with the specifications that have been made
j. When finished, turn off the measuring tool by pressing the on/off button again

D. Data Collection Auto Dripping

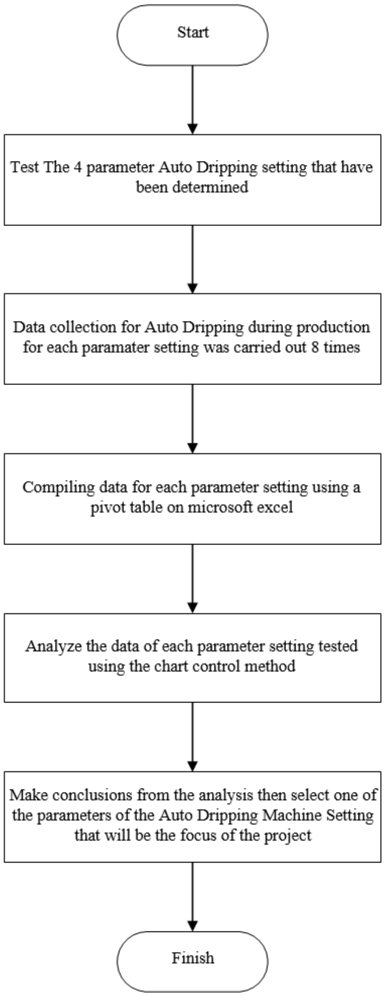

Fig. 2. Flowchart Data Collection Auto Dripping

From the flowchart above, the test data collection for the auto dripping parameter is divided into 3 stages, namely:

1) Data collection.

Test data is obtained by taking a sample of the coating liquid when production is just running with a Cup from a Viscotester, then the sample is brought to the laboratory to measure its viscosity using a Viscotester, then the results of the viscosity measurement are recorded on the check sheet that has been made, then take a resistor sample to measure the body dimensions, then the results of body dimension measurements are recorded in the check sheet. This activity is carried out repeatedly until data collection is complete.

2) Data analysis

After the data has been obtained, then the data is compiled using a pivot table in excel so that the data can continue to be analyzed using a Control chart [10]. So that the desired focus parameters will be obtained so that they can be analyzed and tested in this project

3) Conclusion

After analyzing the data, an initial conclusion will be made as the basis for working on this project. This conclusion will contain the Auto Dripping parameter which will be the main focus of this project based on the data analysis that has been done.

4) Parameter Test

In product research and optimization, a test design is needed. The experimental method steps that will be carried out in this project are:

1. The first step is to set the objective of the experiment as previously explained. The purpose of this experiment is to get the Auto dripping setting parameters that can maintain the viscosity of the coating liquid properly.
2. The second step is to determine the Parameters to be tested, while the variables that can be controlled in Auto Dripping are Stroke Speed and Stroke Length. The variables here are machine settings.
3. The third step is data collection, each parameter to be tested is collected 5 times. The data format to be retrieved is:
4. The fourth step is to analyze and interpret the results of the data that has been taken by selecting one of the parameters that gives optimal results.
5. Confirm submission.

After the experiment is carried out, the results of the experiment will issue output in the form of the resulting viscosity coating stability data and body dimensions. Each experiment produces different data output, it will be analyzed, and conclusions will be drawn from which experimental results are closer to the results of the comparison of actual measurements. Drawing conclusions on the trial parameter settings on Auto Dripping. Then the results obtained will later be categorized whether these results include the desired parameters according to the objectives of this project. After implementing these parameters on the machine for 5 weeks, we will see monitoring data using the Process Capability Index method, so further analysis of the data will be carried out as a conclusion in this project.

TABLE III
PARAMETERS TO BE TESTED

No	Specified methanol output (ml)	Stroke Speed (Spm)	Stroke Length (%)	Test results with measuring cups (ml)
1	40	15	15%	R1(40), R2(40), R3(40)
2	50	30	30 %	R1(50), R2(50), R3(50)
3	60	45	30 %	R1(60), R2(60), R3(60)
4	70	60	45 %	R1(70), R2(70), R3(70)

III. RESULTS AND DISCUSSION

This chapter will discuss the results of testing or experimenting with the auto dripping parameters that have been carried out using the Control Chart method. There were five trials with different setup parameters. Each parameter tested adjusts to a predetermined test table. Each viscosity test will be measured as much as 5 data.

A. Distribution data of each parameter test

Data collection is carried out during the parameter testing process, namely by taking a resistor sample which is then measured to find out whether the sample is in accordance with the specifications. The following is the distribution of data for each parameter tested.

1) Distribution data of parameter 40 ml

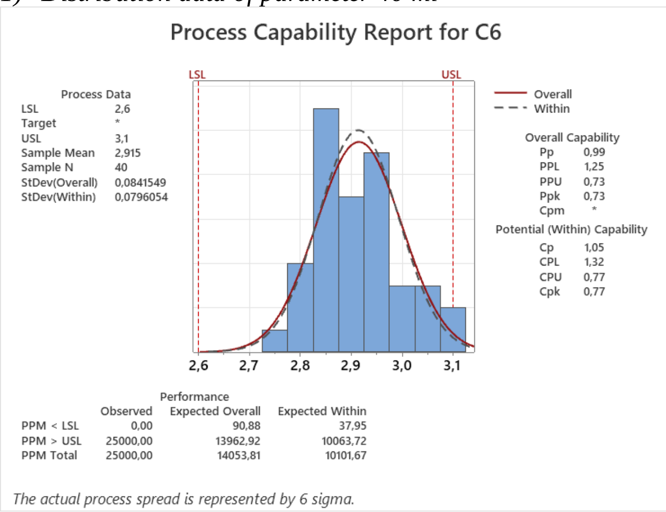

Fig. 3. Distribution of the experimental data parameters 40 ml

After testing the 40 ml parameter, we can see the results of the data distribution shown in the picture. The 40-parameter test still does not meet the specifications and the distribution of data that is in high spec can be said to be not optimal. Meanwhile, the CpK value in this experiment was below the standard specification, namely 0.77.

2) Distribution data of parameter 50 ml

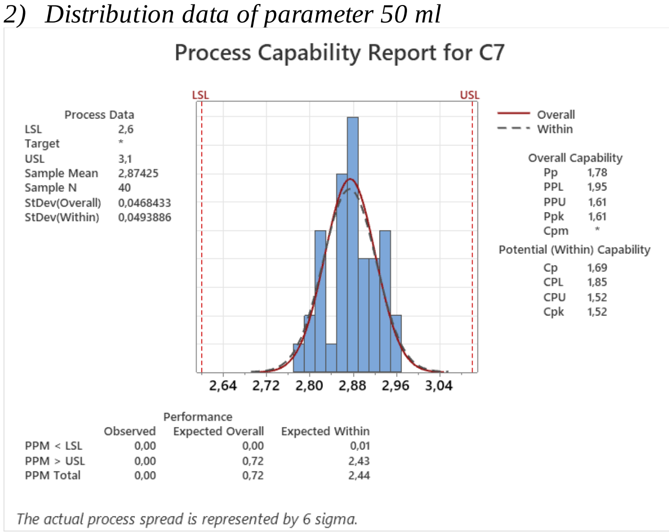

Fig. 4. Distribution of the experimental data parameters 50 ml

After testing the 50 ml parameter, we can see the results of the data distribution shown in the picture. It can be seen that the 50-parameter test still does not meet the specifications and the distribution of data that is in high spec can be said to be not optimal. Meanwhile, the CpK value in this experiment did not meet the standard specifications, namely 1.52.

3) Distribution data of parameter 60 ml

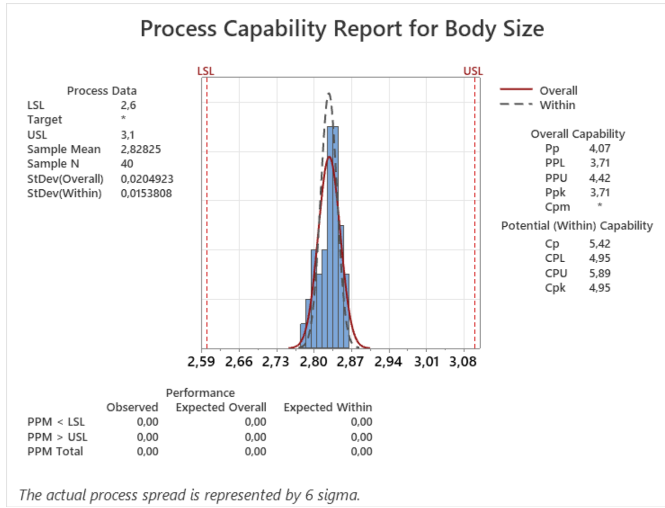

Fig. 5. Distribution of the experimental data parameters 60 ml

After testing the 60 ml parameter, we can see the results of the data distribution as shown in the figure. The 60 ml parameter test meets the specifications and the distribution of data in the center spec can be said to be optimal. As for the CpK value in this experiment according to the standard specifications, namely 4.95

4) Distribution data of parameter 70 ml

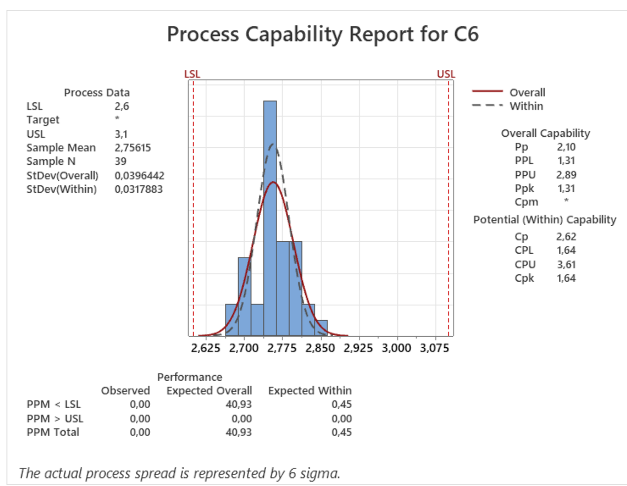

Fig. 6. Distribution of the experimental data parameters 70 ml

After testing the 70 ml parameter, we can see the results of the data distribution as shown in the figure. The 70 ml parameter test meets the specifications and the distribution of data in the lower spec can be said not really optimal. As for the CpK value in this experiment according to the standard specifications, namely 1,64

TABLE IV
THE RESULTS OF EACH EXPERIMENT DATA ON PARAMETERS

Run	Parameter tested			
	1	2	3	4
1	2,95	2,86	2,82	2,75
2	2,90	2,86	2,84	2,80
3	2,96	2,87	2,80	2,74
4	2,86	2,88	2,82	2,75
5	2,89	2,88	2,83	2,71
Mean	2,91	2,87	2,82	2,75
Cpk	0,77	1,52	4,95	1,64
Result	Unstable	Stable	Stable	Stable

B. The overall results of the Auto Dripping parameter test data

In the Auto Dripping parameter, there are two variables that are changed in each experiment, namely Stroke speed, Stroke length. In each experiment there are eight samples that will be the output of each experiment. Each experiment has different parameters, so here is a summary table of the overall test results for each experiment.

Based on the table of data results for each parameter setup experiment on the 4 parameters tested, we can see that there is a significant difference in results, between the 1st experiment to the 4th experiment on the average/mean value, the CpK value obtained. The results of these tests the authors concluded that after testing the Auto Dripping parameter set up the authors obtained experiments 2, 3 and 4 which had a distribution of measurement data or Cpk values with values that met the standard specifications, namely ≥1.5. Then the one with the highest cpk value was 4.95 in experiment 3. Whereas in experiment 1 it only got a value of ≤1.5.

C. The result of the parameter selection analysis to be implemented

After doing the analysis using the Control chart and looking at the distribution of the measurement results data on each experimental result set up parameters. The writer decided to choose the 3rd experimental parameter to be implemented on the Auto Dripping machine. Because only trial 3 measurement results have the Cpk value is the highest and meets the standard, which is worth 4.95, which value is ≥1.5. So, the authors conclude that the Control chart and Capability Analysis are quite effective in finding a more optimal set up parameter, namely the 3rd set up parameter experiment for Auto Dripping.

D. The result of monitoring data analysis after implementation

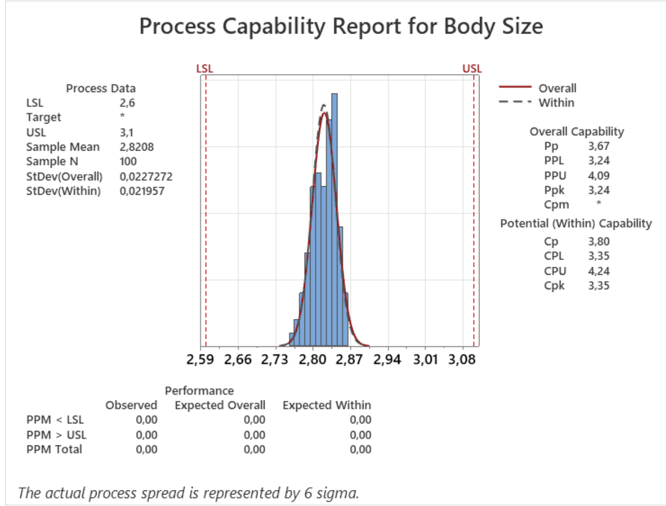

Fig. 7. Distribution of data after the application of parameters

After implementing the Auto Dripping parameter from the results of the previous analysis, the authors look again at the body resistor measurement data after the implementation is carried out. This data has a range of about 5 weeks after implementation. Following are the data:From the data above, it can be seen that the production of resistors has been running stably with a period of 5 weeks, with 100 resistor samples being measured. And we can see the results of the data distribution shown in the figure. The installation of the new parameter setup meets the specifications with the data distribution being at the center spec. With an average value of 2.82 mm. As for the Cpk value after implementing the new parameter setup, which is 3.35, this is a fairly high result and meets the standard, which is ≥1.5. The implementation of the Auto Dripping set up parameter has proven to be quite influential in reducing the case of coating defects caused by uncontrolled viscosity, namely by maintaining the stability of the coating viscosity so that it can produce resistors that meet specifications.

E. The production of Resistor after the implementation of Auto Dripping

The following is comparative data between production resistor in the Finishing process before implementing Auto Dripping and After implementing Auto Dripping:

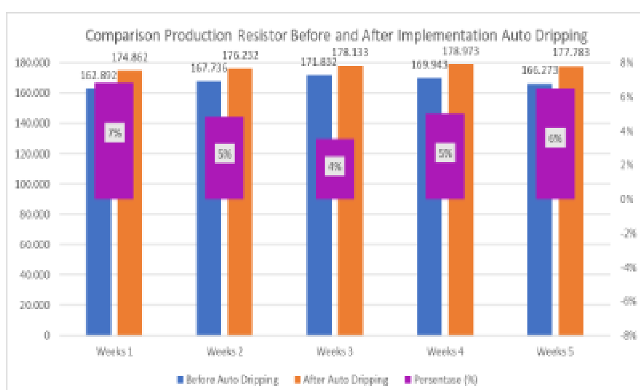

Fig. 8. Comparison data production resistor

From the data above, it can be seen that the comparison of data between the production of resistors before the implementation of Auto Dripping and After the implementation of Auto Dripping in the Finishing process, it can be concluded that from the data obtained during the five weeks of production running, the implementation of Auto Dripping is proven to increase Resistor productivity on average by >5%, from the previous time it had decreased due to the large number of product defects caused by uncontrolled viscosity.

IV. Conclusion

Based on the results of the research that has been done, the following conclusions are obtained: Testing the parameters of auto dripping using the control chart method is quite effective in finding the right parameter setup and according to the desired specifications. The more precise the machine settings, the less error analysis occurs. Because the cause of the error analysis occurs because the auto dripping performance is far from the desired target. Experiments and testing of auto dripping parameters have proven to be quite influential in maintaining the stability of the viscosity of the coating liquid when the machine is working. With a stable viscosity, it can be concluded that it also influences the formation of a better resistor body according to specifications. Using measuring devices has proven to be very helpful in conducting tests and monitoring the viscosity of coating liquids by obtaining measurement results so that they can determine whether the results are in accordance with specifications. From the results of the process capability index obtained, that the use of Cpk in determining the capability of a process can be said to be quite successful, because the data obtained after implementing the parameters on auto dripping is as expected by the author.

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