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The Effect of Process Variables on Work Piece Thickness and Glossiness from Metal Coating in Nickel-Chrome Metal Coating Process

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Abstract. Metal coating process is a lot of choices to improve the quality of materials from metals and non-metals. This is due to the metal coating process, the quality of the material can be maintained both in terms of quality and glossiness. Metal or electroplating coating processes are also used for protection against corrosion attacks and for decorative purposes. The purpose of this study is to determine the effect of immersion time, voltage, and distance of the electrode on the work piece layer thickness and glossiness resulting from metal coating. While the benefits of this study as a reference material for coating methods with various process variables by industry parties engaged in metal coating with electroplating techniques. The research variables are time: 15; 20; and 25 minutes, Voltage: 3; 4.5; and 6 volts, and the electrode distance: 10; 15; and 20 cm, other variables were made constant. The work piece used was made of steel metal the size of the plate size = 200 x 30 x 5 mm³ totalling 54 pieces. The research method used was an experiment with a 3 x 3 x 3 research design. The results of the study can be concluded that the longer the immersion time, the greater the voltage; and the closer the anode-cathode distance, it will affect the thicker the work piece surface layer resulting from metal coating. The smallest thickness of the surface layer was 4.5 μ m to the largest 10.1 μ m. In addition, the greater the thickness of the work piece surface layer as a result of metal coating, the greater the number of glossiness. The smallest glossiness number was 125 lux and the biggest glossiness number was 152 lux.

Keyword: Electroplating, Coating Time, Voltage, Anode-Cathode Distance, Layer Thickness, Layer Glossiness

1. Introduction

Electroplating is a metal layers' deposition process on electrodes that aim to form a surface with properties or dimensions that are different from the original metal [1]. Electroplating is one technique to deal with damage caused by metals corrosion and also serves as a resistance to the original material. Besides that, plating also provides aesthetic value to the metal to be coated, namely certain colours and textures, also to reduce contact resistance and increase surface conductivity or reflectivity.

The increasing number of equipment uses, accessories, property and others that use metal coatings will spur to continue to maintain the result quality of metal coating. To get the maximum



metal coating function, a medical device must be coated with silver metal to sterilize it from deadly bacteria when used for surgery. However, the coating results must be consistent based on thickness. In the nickel layer industry in Sidoarjo Indonesia, especially in small industries which are generally engaged in coating services, have products that do not fulfil the quality requirements. This is because the layer is very thin and easy to peel. easy to rust, and the colour is less glossy. These results can occur due to incomplete processes, the operating conditions choice that are less precise and the technology that is owned is still very simple [2]. Therefore, it is necessary to improve the process, starting from the initial process, i.e. the mechanical and chemical cleaning process [3]. Then in the coating process itself the optimum and appropriate operating conditions are set, for example by determining the immersion time length, the anode-cathode distance, and the appropriate electrical voltage needed [2].

Cathode distance, time and voltage used in the electroplating quality [4]. This study aims to determine the surface layer thickness and the glossiness of the work piece resulting from metal coating.

2. Method

Metal made of AISI 1015 steel. Chemical composition of AISI 1015 steel (5% by weight): 0.15C, 0.082Mn, 0.166 Si, 0.054P, 0.15S, and Bal. Fe. Therefore, the experiment design was a factorial influence model. The response variable in this study was the work piece layer thickness and glossiness resulting from metal coating. As the independent variable was the time, voltage and distance of the cathode anode. There were three levels of coating time, namely 15, 20 and 25 minutes. The voltage also had three levels, namely 3, 4.5 and 6 volts. And the cathode anode distance had three levels, namely 10, 15 and 20 cm. Control variables were the work piece type, PH, and electric current. Experiments were performed randomly without replication. Thus the result was 27 observations for the experiment.

The research procedure began with preparing a work piece of size, and cleaning the work piece in a polished manner. Cleaning with scrubbing grids of 100, 500, 1000, 1500 and 2000. After that the work piece was weighed to determine its initial weight. We cleaned the work piece with a cleaning solution (HCl), also prepared metal coating equipment with a nickel layer and chrome layer. Install the work piece to the cathode pole, and the coating metal at the anode pole. Set the machine based on the research variables, and put them in solution. After finishing the metal coating process, we weighed the work piece first and then we tested the thickness of the surface layer. Continued to test the gloss of the work piece surface layer.

3. Results and Discussions

3.1. Layer Thickness Testing

Data from testing results of the work piece layer thickness from the metal coating results are as follows.

Table 1. Data from the testing results of the workpiece layer thickness

No	Time (minute)	Voltage (volt)	The distance of the anode- cathode (cm)	Thickness test (um)			Average (um)
				I	II	III	
1	15	3	10	4,5	4,6	4,4	4,5
2	15	3	15	4,0	4,2	4,1	4,1
3	15	3	20	3,6	3,9	3,9	3,8
4	15	4,5	10	6,0	6,3	6,3	6,2
5	15	4,5	15	5,6	5,7	6,1	5,8
6	15	4,5	20	5,3	5,4	4,9	5,2

7	15	6	10	7,7	7,5	7,6	7,6
8	15	6	15	7,0	7,4	6,9	7,1
9	15	6	20	6,4	6,6	6,5	6,5
10	20	3	10	6,4	6,4	6,1	6,3
11	20	3	15	5,5	5,6	6,0	5,7
12	20	3	20	5,1	5,3	5,2	5,2
13	20	4,5	10	7,7	7,5	7,6	7,6
14	20	4,5	15	7,2	7,3	6,8	7,1
15	20	4,5	20	6,7	6,9	6,8	6,8
16	20	6	10	9,0	9,2	9,1	9,1
17	20	6	15	8,4	8,5	8,9	8,6
18	20	6	20	8,0	8,1	8,5	8,2
19	25	3	10	7,6	7,7	7,8	7,7
20	25	3	15	7,0	7,1	7,5	7,2
21	25	3	20	6,9	6,6	6,9	6,8
22	25	4,5	10	9,0	9,3	9,3	9,2
23	25	4,5	15	8,5	8,7	8,6	8,6
24	25	4,5	20	8,3	8,0	8,3	8,2
25	25	6	10	10,0	10,2	10,1	10,1
26	25	6	15	9,4	9,8	9,9	9,7
27	25	6	20	9,2	9,6	9,7	9,5

After the layer thickness testing, data was obtained. The results obtained were made in graphical form as can be seen in Figures 1 to 3 below.

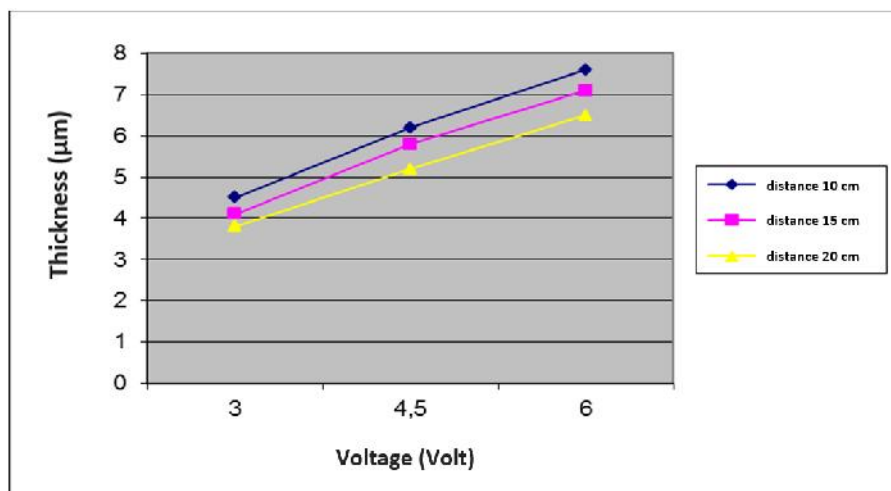


Figure 1. Thickness graph of metal coating results in 15 minutes

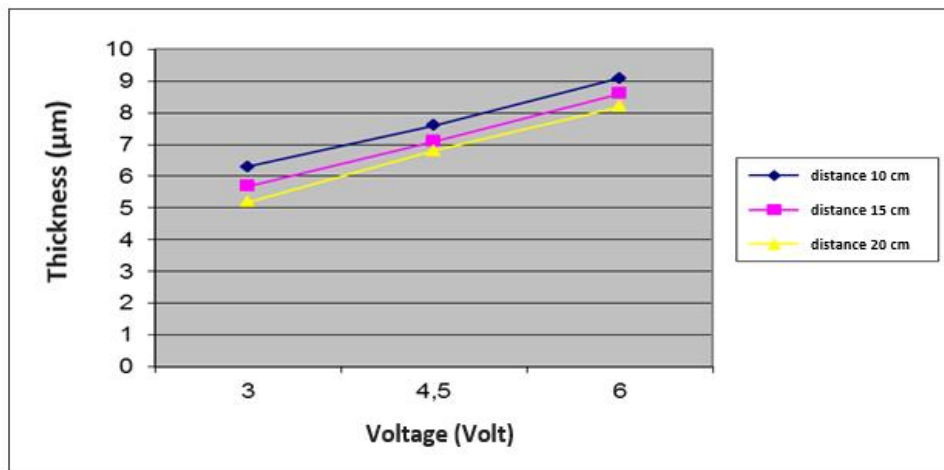


Figure 2. Thickness graph of metal coating results in 20 minutes

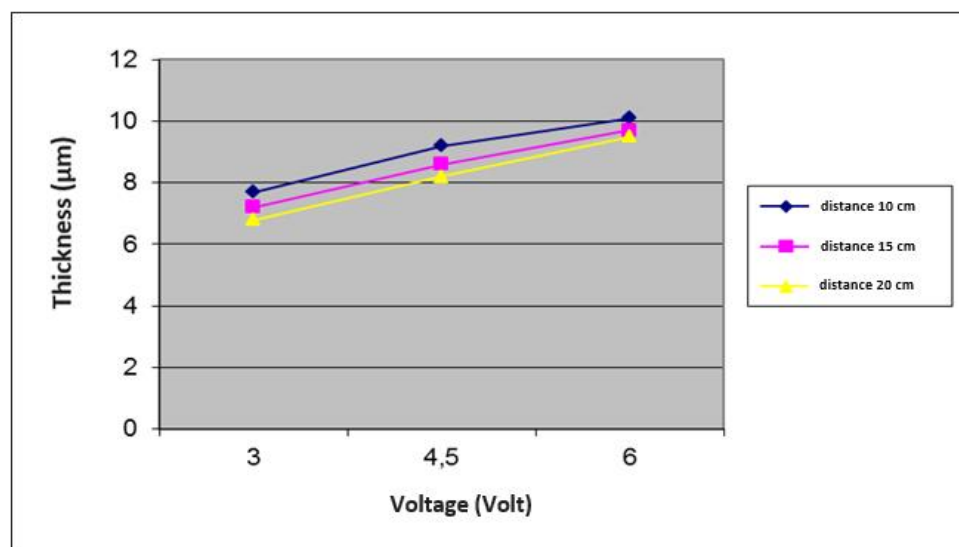


Figure 3. Thickness graph of metal coating results in 25 minutes

The electroplating process affected the surface thicknesses number of the workpiece resulting from metal coating. On the use of the metal coating process, the thickness was 3.8 μm . In figure 1 to figure 3 we can see that at 15, 20, 25 minutes the thickness ranging from 4.5 μm to the highest 10.1 μm , which increases due to the longer immersion time of the workpiece into the solution, it will make

the available length of time longer for the process of attaching positive ions carrying coating metal deposits (nickel and chromium) dissolved in the solution has the opportunity to stick perfectly and evenly [5,6].

For the greater voltage given, the energy potential between the metal to be coated (steel) and the coating metal (nickel and chromium) had a difference in value that was farther away, so that the atomic bonds inside the coating metal (nickel and chromium) broke down. The electrons that have been decomposed will move to the metal to be coated through a conductor in the form of a copper wire or cable connecting the two metals. With the greater voltage given, the more electrons move or release to the coating metal and bond new atoms with positive ions which bind to the deposited metal which will make the thickness of the layer thicker and the surface becomes even.

The anode-cathode distance also determines the faster the metal coating process occurs. With the distance between the anodes, the positive ions in the solution will be longer to stick to the surface of the coated workpiece. The anode-cathode distance also determines whether the surface of the workpiece carried out by the electroplating process can be perfectly coated or not. The electrons displacement from eroded metal and the atoms bonding decomposed through the conductive wire is also increasingly extended, along with the distance between the anodes and cathodes. This causes the surface of the workpiece to be performed by the electroplating process to be less perfect and uneven [7,8].

3.2. Glossiness Testing

Table 2. Data from testing the workpiece layer glossiness

No	Time (minute)	Voltage (volt)	The distance of the anode- cathode (cm)	Gloss Testing (lux)			Average (lux)
				I	II	III	
1	15	3	10	132	133	131	132
2	15	3	15	128	130	129	129
3	15	3	20	122	128	125	125
4	15	4,5	10	136	138	134	136
5	15	4,5	15	135	134	136	135
6	15	4,5	20	134	132	136	134
7	15	6	10	140	139	141	140
8	15	6	15	137	139	138	138
9	15	6	20	138	137	136	137
10	20	3	10	137	138	139	138
11	20	3	15	136	134	138	136
12	20	3	20	135	133	137	135
13	20	4,5	10	140	140	143	141
14	20	4,5	15	140	139	141	140
15	20	4,5	20	138	139	140	139
16	20	6	10	147	146	145	146
17	20	6	15	145	144	143	144
18	20	6	20	143	141	142	142
19	25	3	10	141	142	143	142
20	25	3	15	142	140	141	141
21	25	3	20	140	139	141	140
22	25	4,5	10	147	147	144	146
23	25	4,5	15	145	146	144	145
24	25	4,5	20	143	144	145	144
25	25	6	10	151	152	153	152
26	25	6	15	149	150	148	149
27	25	6	20	148	149	147	148

After retrieving glossiness test data, the results obtained were made in graphical form as can be seen in Figures 4 to 6 below.

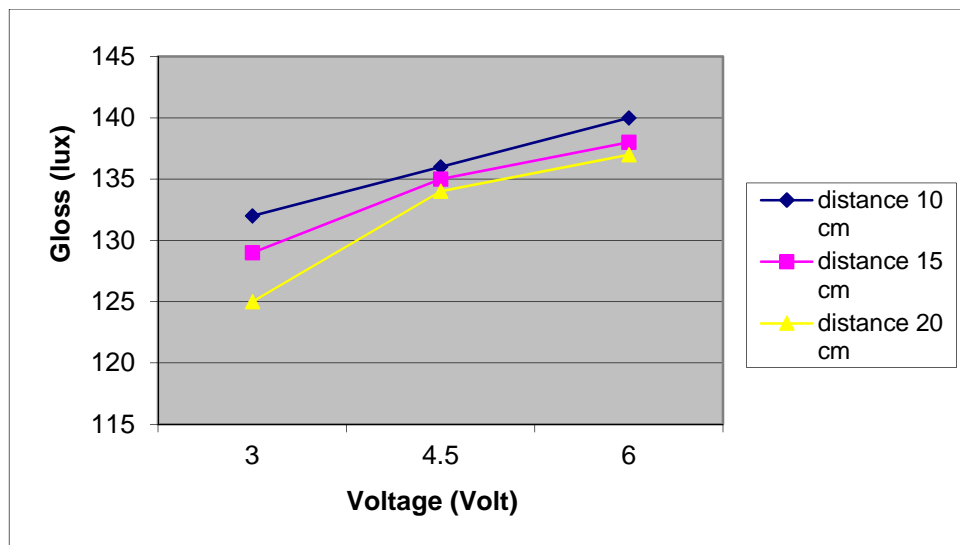


Figure 4. Glossiness graph of metal coating results in 15 minutes

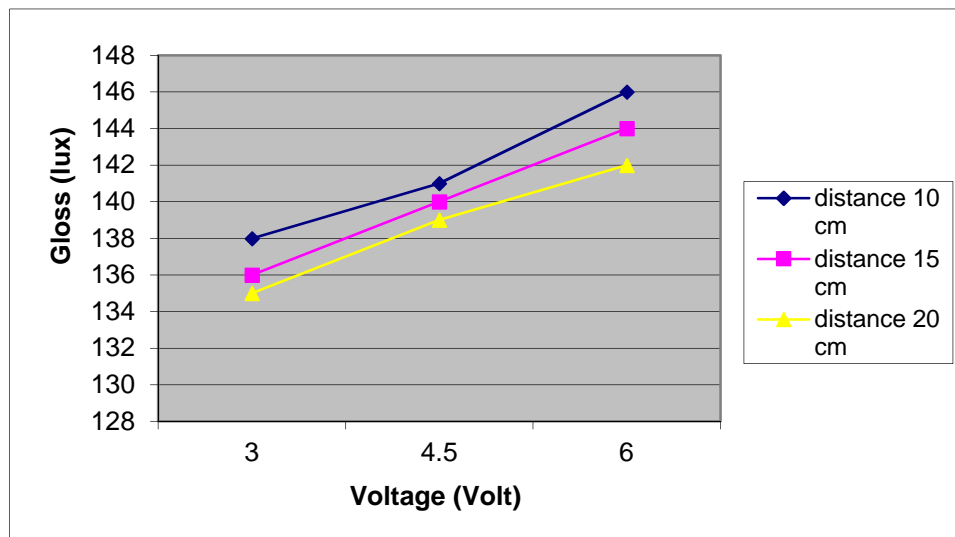


Figure 5. Glossiness graph of metal coating results in 20 minutes

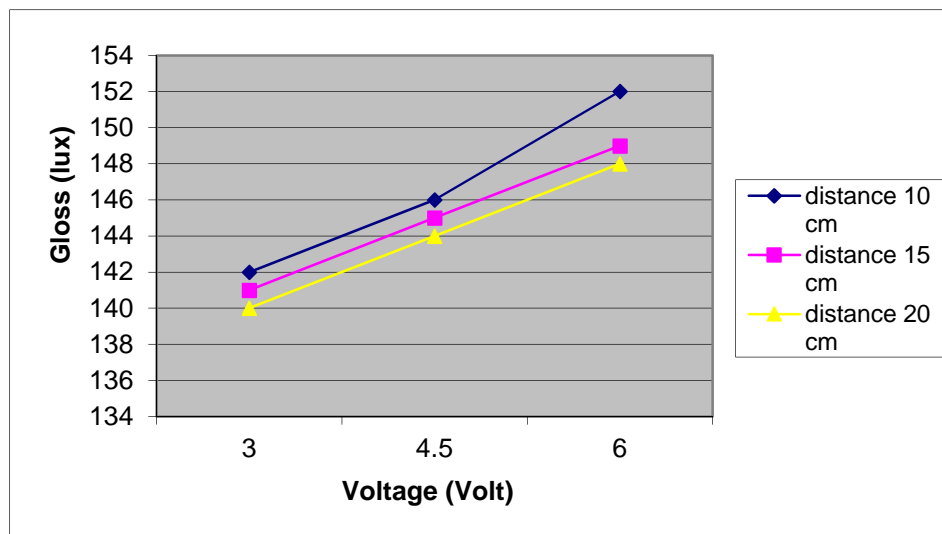


Figure 6. Glossiness graph of metal coating results in 25 minutes

The effect of immersion time on the level of workpieces glossiness is strongly influenced also by the workpiece thickness resulting from the metal coating process. The glossiness numbers in table 2 show that the lowest glossiness number was 125 lux and the biggest glossiness number was 152 lux. The longer the immersion time, the thicker the layer of nickel and chromium will be, the more the glossiness layer of the workpiece will be more glossy. The resulting surface will be more tightly and perfectly arranged, so that the properties of glossy nickel-chrome metal when exposed to light will make the level of glossiness become higher than the thin layer thickness [7]. The formed layer will control the occurrence of corrosion [9-12].

The voltage on the metal coating process also determines the degree of workpiece glossiness resulting from metal coating. This metal coating process must be performed with a voltage that is not too large but performed for a long time, but the voltage used when the metal coating process is still within safe limits and does not cause the surface to become dull and not glossy. With a voltage that is too large it will make the process of transferring electrons to the workpiece surface to be coated faster than the process of forming bonds between electrons and positive ions in the solution. Therefore the greater the voltage will make the thicker the layer, and the higher the value of gloss produced.

The anode-cathode distance makes the process of transferring positive ions in the solution longer with the distance. With greater distance, the positive ions will be long and difficult to stick to, and the surface layer is unevenly attached. The farther the distance of the anodes is, the thinner the layer and the tendency to stick to it occurs a lot on one side, the thickness is uneven which results in a low gloss level.

4. Conclusions

The research results conducted can be concluded as follows:

1. The longer the immersion time, the greater the voltage, and the closer the anode-cathode distance, it will affect the thicker the workpiece surface layer resulting from metal coating. The smallest thickness of the surface layer is 4.5 μm until the biggest is 10.1 μm .
2. The greater the thickness of the workpiece surface layer as a result of metal coating, the greater the number of glossiness. The smallest glossiness number is 125 lux and the biggest glossiness number is 152 lux.

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