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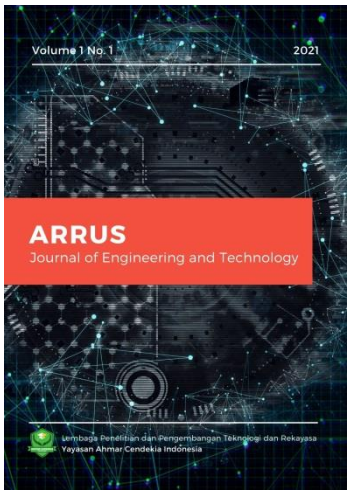

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RESEARCH ARTICLE

Material Test Comparison of Pure Aluminum (Al) and Pure Aluminum-Coated (Al) with Silver (Ag) Substrat Using Electroplating Method

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Abstract: Electroplating uses aluminum material, where it's easy to obtain, lighter, and cheaper than other metals. The research goal was to determine the ability of the electric current to power aluminum (Al) coated with silver (Ag) by the electroplating method, to determine the effect of the magnitude of the electric current and the length of time the coating process took on the weight of Al coated with Ag and to determine the strength of the metal Al after tested using Brinnell test. The method used is to compare pure Al and pure Al coated with Ag by electroplating at different currents to determine the effect of the electroplating process. A Brinnell test was carried out to determine the hardness of the Al material after electroplating. The results are the amount of current that flows during the electroplating is directly proportional to the thickness of the electroplating layer attached to the Al surface. If the electroplating process uses a large current, the attached layer will look rough and not smooth, which also affects the material testing by using the Brinnell method. The Brinnell test proves that the hardness value of the Al material is directly proportional to the thickness of the layer.

Keywords: Electrical Current, Electrodeposition, Electrolyte, Metal Coating, Plating.

1. Introduction

Electroplating is a method of metal plating which is also called electrodeposition, which is a process of deposition or deposition of protective metal on metal by electrolysis (Saleh, 2014). Giving a layer to an object is adding a new element to add advantages to the object according to the desired properties (Assegaff & Purwanto, 2018). In addition to these objectives, electroplating is also able to improve the quality and aesthetic value of the product. Electroplating can be used as a means to facilitate the process of conducting electricity at the connection between metals. As for the metal coating in terms of the electrochemical properties of the coating material, it can be categorized as anodic coating and cathodic coating. Anodic coating is where the electroplating potential of the coating metal is more anodic concerning the base metal or substrate, while the cathodic coating is a coating in which the electrolytic potential of the coating metal is more cathodic for the substrate (Basmal et al., 2012).

The use of electroplating to facilitate the conduct of electricity is commonly used for conductors in Gas Insulated Switchgear (GIS). Conductors in GIS usually use aluminum as

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a base material that is coated with silver (Ag) at the ends to make it easier to conduct electric current. The electroplating process is a series of DC (Direct Current) electric current, electrodes (anode and cathode), electrolyte solution, and the workpiece is placed as the cathode (Ansari et al., 2017).

During the electroplating process, several factors influence it so that the desired results are good and maximum, namely potential difference, current density, coating thickness, temperature, solution concentration, and coating time. The thickness of a coating process will reduce surface damage to the metal and make it easier to conduct electric current on aluminum metal coated with silver. Thickness is influenced by the length of the process and also how much stress is applied (Suarsana, 2008). Therefore, research is needed so that people know about the electroplating method which is very useful in the process of conducting electricity. For this reason, the author will try to experiment with pure aluminum material compared to aluminum that has been coated with silver (Ag) through the electroplating method and then will end with Brinnell testing of materials with various variations of current strength.

2. Literature Review

2.1. Anode and Cathode

The anode can be used as a coating material in the electroplating process. The role of the anode is very important in producing the quality of the coating. The influence of purity or cleanliness of the anode on the electrolyte and its determinants, optimization of the size and shape of the anode needs to be considered or considered. Careful consideration or calculation in determining the anode in the coating process provides advantages, namely increasing production efficiency and reducing the emergence of problems in the coating process. There is an electric current flowing through the electrolyte solution between the two electrodes, then at the anode, there will be the release of metal ions and oxygen (reduction), then metal ions and hydrogen gas are deposited on the cathode electrode. This event is known as the coating process with a soluble anode or soluble anode. But if the anode is only used as a conductor of current, this anode is called an insoluble anode. From the dissolved anode metal ions will be formed, when metal atoms are oxidized and release electrons that are proportional to the electrons from the cathode. Metal ions are reduced back continuously in metal atoms, then deposited at the cathode. Insoluble anodes are alloys of materials such as nickel steel, lead-tin alloy, carbon, platinum titanium Metal ions are reduced back continuously in metal atoms, then deposited at the cathode. Insoluble anodes are alloys of materials such as nickel steel, lead-tin alloy, carbon, platinum titanium Metal ions are reduced back continuously in metal atoms, then deposited at the cathode. Insoluble anodes are alloys of materials such as nickel steel, lead-tin alloy, carbon, platinum titanium (Suarsana, 2008). In the electroplating process, the cathode is the workpiece to be coated, connected to the negative pole of the electric current source. Two metal plates are anode and cathode connected to the positive and negative terminals of the direct current (DC) source (Topayung, 2011).

2.2. Electrolyte Solution

Electrolyte solutions can be made from solutions of acids, bases, and metal salts that can form positive ions. For each type of coating, the electrolyte solution is different depending on the desired electrolyte properties. Electrolyte solutions always contain salts and the metal to be coated. Therefore, the salts should be chosen which are easily soluble, but the anions are not easily reduced. The alkaline solution (alkali) which is widely used in the electroplating process is the cyanide complex salt because the cyano (free cyanide) complex is decomposed by acid. Electrolytes are substances that can conduct electric currents. The electrolyte used in the form of an acid or base solution is mixed with pure water (Rasyad & Budiarto, 2019).

2.3. Current Source

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The electroplating process can take place if there is a direct current source. A rectifier is an equipment that is widely used in the electroplating process because it functions as direct current (DC) and functions to lower the voltage (Mappa et al., 2020). Alternating current from a power source will be reduced in voltage through a transformer, the voltage that has been lowered is then submitted using a diode in the bridge stone system. At the moment the rectifier is quite efficient. This is because the ammeter, the variable resistance is located as a unit in one circuit (Topayung, 2011).

2.4. Electroplating

Research has been found on the effect of time on the quality of the coating on copper material. And the data provides an overview of the increase in coating thickness, and also the brightness level of the material when electroplating increases. When the processing time is increased, the brightness of the resulting material will decrease even more (Suarsana, 2008). The anode-cathode distance affects the thickness of the nickel layer made. In this experiment, the highest thickness is shown in the sample with the closest anode-cathode distance (10 cm) which is 30 m. However, the uniform thickness of the nickel layer in this sample is very lame, resulting in a very coarse layer. Meanwhile, a thinner but uniform nickel layer is shown by samples 2 and 3 with anode-cathode distances of 15 cm and 20 cm (Hutauruk, 2018). Electroplating will provide an even surface coating on the surface with good results, due to accurate checks that can be carried out on all processes. In addition, there is no heat treatment on the material to be coated so there is no risk of damage to the mechanical properties of the material. Electroplating is also a coating technique that is easy to work with, simple, and economical, but will produce a satisfactory product (Saefuloh et al., 2017).

Copper material is one of the metals that have soft and ductile properties, therefore, copper will be more easily deposited by other materials that have a higher electromotive force than copper. The electroplating coating of copper material will certainly be easier to process and the electrolyte solution will also be easier to check and control (Mulyadi, 2018). Materials for this type of aluminum (Al) usually have good mechanical properties and also depend on the heat treatment of the material. In addition, pure aluminum (Al) has moderate tensile strength, is easy to form, and has excellent weldability. Because of its good mechanical properties, aluminum 6061 is widely used in ship construction, building frames, materials for aircraft, milk cans, and also food packaging or vehicle wheels (Gunawan, 2016). Aluminum metal (Al) is widely used as a material for many components because it has superior properties, including lightweight, high strength, and ductility, easy to fabricate (Andayani et al., 2017). We hypothesized by the following:

H1: The amount of current that flows during the electroplating process is not directly proportional to the thickness of the electroplating layer attached to the surface of aluminum (Al) with the results of the Brinnell test proving that the hardness value of aluminum (Al) material is not directly proportional to the thickness of the layer.

H2: The amount of current that flows during the electroplating process is directly proportional to the thickness of the electroplating layer attached to the surface of aluminum (Al) with the results of the Brinnell test proving that the hardness value of the aluminum (Al) material is directly proportional to the thickness of the layer.

3. Materials and Research Method

3.1. Materials

The materials that have been used for this research are pure aluminum (Al) without electroplating with a diameter of 40 mm and a thickness of 4 mm, solutions (alkaline washing solution, acid clean solution, water, deep zinc solution, Cu plating solution or Copper, Ag strike solution, Ag plating solution). The following instruments have been used: Rectifier, Ampere Pliers, Thickness Tester.

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3.2. Research Method

We refer to (Selly et al., 2020) for the electroplating process procedure. After doing the electroplating process, we tested for metal testing by used the Brinnell test method. In addition to the Brinnell method which is the most effective in testing materials, the Brinnell method is also easy to use and the test results will be read quickly. The working principle of the Brinnell method is to press the indenter for 30 seconds, then the diameter of the indentation can be measured using an optical microscope. The diameter must be calculated twice at different perpendicular angles, then leveled. When using an automatic Brinnell, it is enough to press the indenter for 30 seconds, then the results can be seen on the monitor of the measuring instrument. The Brinnell hardness test was carried out to determine the effect of heat treatment and cooling variations on the hardness value and the original specimen being tested (Kirono & Julianto, 2008). Brinnel hardness number (BHN = Brinnel Hardness Number) or better known as BH will be adopted. For standard test balls with a diameter of 10 mm, the Brinnell test can also use an indenter with a smaller size, for example with an indenter with a diameter of 5 mm or even smaller. Meanwhile, the susceptible test load that can be used in the Brinnell test is 1 to 3000 kilograms-force (kgf) and using a load application time of 10 to 15 seconds for iron and steel, and soft metals at least using a pressing time of 30 seconds.

4. Results and Discussion

The results of testing Aluminum (Al) that has been coated with silver (Ag) using the electroplating method with variations in current strength, data on the ratio of the thickness of the material to the current strength is determined depending on the thickness of the material. This can be seen in Figure 13 to determine the ratio of the thickness of the material to the current strength.

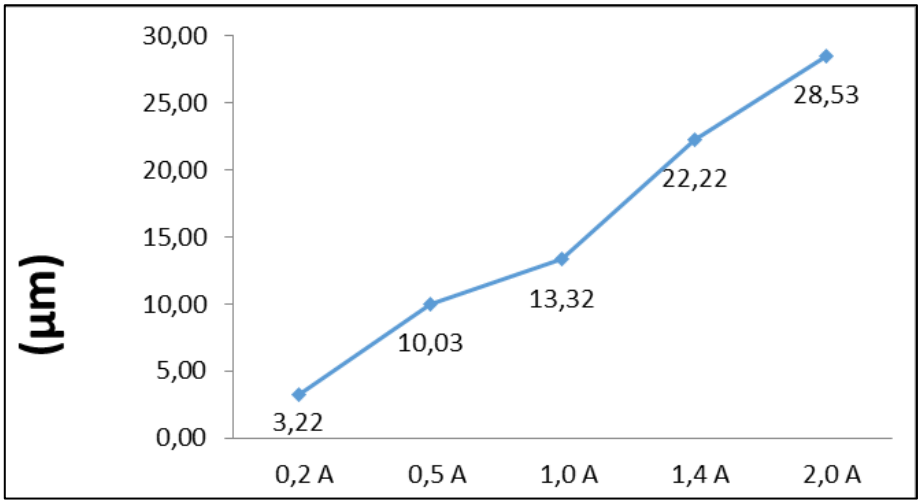

Figure 1. Result of comparison of a material thickness (in micrometers) with current (ampere).

Based on Figure 13, it can be seen that the resulting coating will continue to get thicker, due to the greater current strength. At a current of 0.2 amperes, the thickness is 3.22 m, for a current of 0.5 amperes, the thickness is 10.03 m, for a current of 1 ampere the thickness is 13.32 m, for a current of 1.4 amperes the thickness is 22.22 m, and for a current of 2 amperes. the thickness of 28.53 m. Figure 14 shows the comparison of material hardness with variations in current strength.

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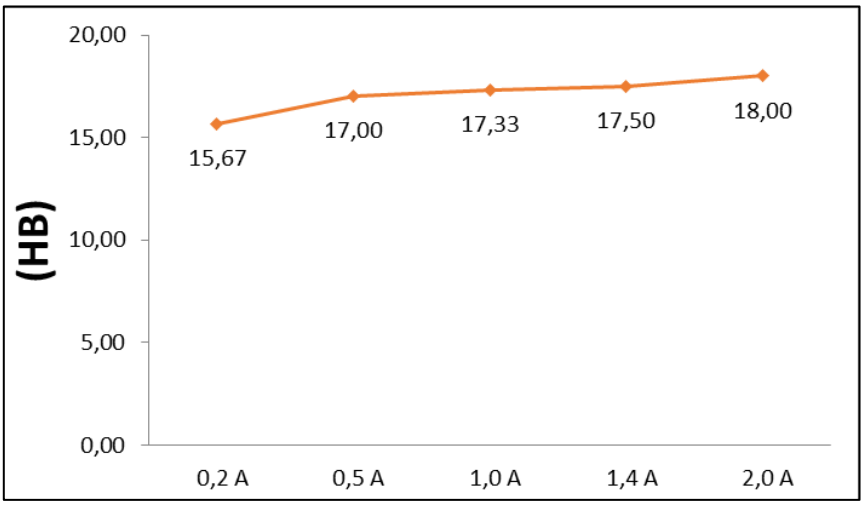

Figure 2. Result of comparison of a material hardness (in HB) with current (ampere).

Based on Figure 14, shows that the hardness of the test material will get harder, due to the influence of the plating layer that coats the material getting thicker and the electrical current used is also getting bigger. At a current of 0.2 amperes, the material hardness is 15.67 HB, at a current of 0.5 amperes the material hardness is 17.00 HB, at a current of 1 ampere the material hardness is 17.33 HB, at a current of 1.4 amperes the material hardness is 17.50 HB and at a current of 2 amperes the hardness of the material is 18.00 HB.

Based on Figures 13 and 14, the material compared between pure Al and pure Al-coated with Ag substrates gave good Brinnel test results to avoid corrosion of metals or other applications. Pure Al metal type with pure Al-coated acts as a cathode (connected to the electrical negative pole). The coating metal uses an Ag substrate which acts as an anode (connected to the positive electric pole) (Selly et al., 2020). Cu Plating has a function as a layer of copper (Cu) on Al metal. In addition, a sufficient concentration of Ag strike solution is used which is useful in the initial coating process by applying high stress to the material for several seconds. This is also added with an Ag plating solution in the form of f-KCn with a concentration of 90-100 g/L. This Ag plating process is a silver plating process by utilizing a strong current and time reference, to achieve the desired plating thickness. The electrolysis reactions are (1) and (2):

$$Anode = Ag_{(s)} \rightarrow Ag^{+}_{(aq)} + e^{-} \quad (1)$$

$$Cathode = Ag^{+}_{(aq)} + e^{-} \rightarrow Ag_{(s)} \quad (2)$$

Based on the electrolysis reaction equations (1) and (2) at the anode there is an oxidation reaction of Ag to silver ions (Ag^{+}). Ions (Ag^{+}) will be released into deep zinc solution, Ag strike solution, Ag plating solution to combine ions (Ag^{+}) so that at the cathode there is a reduction reaction of ions (Ag^{+}) to Ag metal which is then deposited on each pure Al metal. and pure Al-coated. This process continues until the ions (Ag^{+}) are completely reduced and each pure Al and pure Al-coated metal is coated with a silver (Ag) substrate. The reaction that occurs can be seen in the following chemical equation (3).

$$Al_{(s)} + 2Ag^{+}_{(aq)} \rightarrow Al^{+}_{(aq)} + 2Ag_{(s)} \quad (3)$$

The quality of the electroplated silver coating can be seen from the uniform morphology and thickness of the coating. This is strongly influenced by the distribution of electric current density. The thickness of the silver layer will not be uniform if the current density is not well distributed (Selly et al., 2020).

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5. Conclusion

During the electroplating process, the strong current used affects the thickness of the plating layer (directly proportional to the amount of electric current used), the greater the current used, the thicker the plating layer attached to the material, besides the length of time used during the electroplating process also affects the thickness plating layer. The aluminum (Al) material that has been coated with a plating layer will harden, especially on the surface of the material. We suggest further research for the types of materials other than aluminum and silver coating in the electroplating process, we are limited to the results of the comparison of tests between pure aluminum (Al) materials and aluminum-coated (Al) on the type of silver (Ag) coating only.

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