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ELECTROPLATING METHOD ON THE FUEL TANK MATERIAL TO PROTECT AGAINST CORROSION

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Abstract

Bioethanol has abundant raw material availability in Indonesia; The disadvantage of bioethanol is that it is hygroscopic so it can cause corrosion. The electroplating method with nickel and chrome plating can make the material corrosion-resistant. The electroplating results were tested for hardness, it was found that the hardness value increased because Ni-Cr ions were successfully deposited. Based on the SEM-EDS test results, it is known that the electroplating process went well, the surface of the material was coated with Ni-Cr elements, where 43.0% of the chrome element was deposited, 17.7% of the nickel element, and other elements, based on the test results, the surface was evenly coated and well, so that the test material does not come into direct contact with the environment, which causes the test material to become passive and protected from corrosion.

Keywords: Bioethanol, Corrosion, Electroplating, Surface coating.

1. Introduction

Corrosion is one of the important phenomena in industry. Many research on corrosion has been well-documented [1-6]. Corrosion on fuel tank materials occurs for several reasons, including because tank materials made of carbon steel are directly exposed to carbonic acid which is formed due to the use of a mixture of gasoline and bioethanol. Therefore, it is necessary to take steps to prevent corrosion on the tank, namely by coating the surface of the tank using nickel and chrome, so that it is more corrosion-resistant.

Biofuels in the form of bioethanol have been recognized as a renewable energy source that significantly reduces carbon dioxide (CO_2) and other greenhouse gas emissions [7-9], so bioethanol is a fuel that is promoted throughout the world as an alternative fuel. Apart from the advantages of using bioethanol which can reduce exhaust emissions significantly, bioethanol also has a weakness, namely that it has hygroscopic properties which cause bioethanol to be corrosive [10, 11] such as the results of previous research regarding uniform corrosion and pitting behavior of steel in ethanol solutions [12, 13]. The corrosion process occurs because of the oxygen contained in bioethanol. The oxygen in bioethanol reacts with the hydrogen in the fuel to form H_2O. The CO_2 content in the fuel then reacts with the H_2O that is formed and forms carbonic acid (H_2CO_3). The more carbonic acid there is in the solution, the pH will tend to decrease so that the acidity of the solution increases [14].

The effort to protect the tank material from corrosion attacks in the environment of gasoline fuel mixed with bioethanol is to make the material passive to its environment. Electroplating is a material surface coating technique that is used to protect the material surface from corrosion attacks because the coating metal will break interaction with the environment thereby avoiding the oxide process [15]. Electroplating can protect steel surfaces from corrosion attacks. Tank materials that have been coated with inorganic substances through an electroplating process will be more resistant to corrosion because the material is not in direct contact with the environment but rather inorganic substances that cover the surface of the tank material. Until now, research on corrosion due to bioethanol fuel has focused more on corrosion studies. However, in-depth research to determine the process of preventing corrosion in materials that are directly exposed to bioethanol fuel is still very rarely carried out, even though corrosion is a dangerous thing, especially corrosion in fuel tank materials because it can cause leaks that result in corrosion, in a fire or even an explosion and life threatening [16]. Therefore, research on corrosion prevention is very necessary as the latest study material for researchers and the manufacturing industry.

2. Literature Review

Electroplating is the event of the transfer of metal ions that settle on a conductive solid object to form a metal layer which is assisted by an electric current through the electrolyte [17]. The layer that settles is called a deposit. The deposition process on the cathode occurs due to the continuous movement of ions using a constant voltage, finally, the ions settle and stick firmly to form a surface layer. The electroplating method has many advantages, with an attractive, simple, and cheap technique, besides that many materials can be plated, such as metals, alloys, and semiconductors, without a maximum deposit thickness [18].

Nickel is a ferromagnetic material, but if the temperature is above 352°C it is paramagnetic. In electroplating, nickel is usually used as a catalyst. Nickel is a metal coating that is very sensitive in its response to coating additives [19, 20]. Nickel is a metal that is widely used in the metal plating industry, has good corrosion resistance and hardness, and has good electrical conductivity. Chrome is a coating that has complex properties, is bluish-white, is heat resistant, and is corrosion resistant [21, 22]. In chrome plating, the chromium ions given as a coating only come from ions in solution, not from the anode, because the anode in the chrome plating process is an insoluble anode. This is because there is no chromium in pure solid form, and the anode must be corrosion-resistant to corrosive chromium solutions. Hard chrome plating (hard chromium) is a chrome plating process where chrome is deposited directly on the base metal. Hard chrome plating is done because it utilizes the properties of chrome. Thus, it has advantages, especially in terms of resistance to heat, corrosion, erosion, and a low coefficient of friction [23].

3. Method

The research method is an experimental method where corrosion control and prevention engineering uses coating technology. One form of coating is electroplating, also known as surface coating, which is an electrodeposition process to produce a dense, homogeneous, and sticky layer in the form of a metal or alloy that adheres to the surface using an electric current. The resulting layer functions as a protector/insulator that improves the specific physical and chemical properties of the surface, in this case, corrosion-resistant properties. The material that has been electroplated is then tested using X-ray fluorescence, Scanning Electron Microscopy (SEM), and Energy Dispersion Spectroscopy (EDS), and also tested for hardness.

4. Results and Discussion

The electroplating process is carried out with two coatings, namely nickel plating and chrome plating. Nickel plating fluid consists of nickel sulfate, nickel chloride, boric acid, brightener carrier, maintenance, and wetting agent. In contrast, chrome plating liquid consists of chrome oxide, sulfuric acid, sulfuric acid, and a brightener carrier. In the nickel plating process, the working voltage is 3 Volts with a current of 0.5 Amperes; in the chrome plating process, the working voltage is 12 Volts with a draft of 24 Amperes. The electroplating treatment for each material varies from 40 minutes to 50 and 60 minutes (Fig. 1).

Fig. 1. Electroplating media.

The electroplating process changes the physical appearance of the material because the electroplating process causes nickel and chromium ions to deposit on the test material so that the physical appearance becomes different as in Fig. 2. Apart from the physical appearance changing, the mechanical properties also increase. To determine changes in mechanical properties, a test is carried out - the hardness of the material.

(a) Non-plating material **(b) Nickel plating** **(c) Chrome plating**

Fig. 2. Types of materials that have not and have been electroplating.

Based on Figs. 3 and 4, the effect of electroplating on the test material causes an increase in hardness, and the longer the treatment time, the more the hardness value increases [24-26]. This is due to the properties of nickel, which are hard, ductile, and has relatively high electrical and thermal conductivity, blending with the test material, as well as the heat-resistant, corrosion-resistant properties of chrome, blending with the test material, thereby increasing its quality [27, 28].

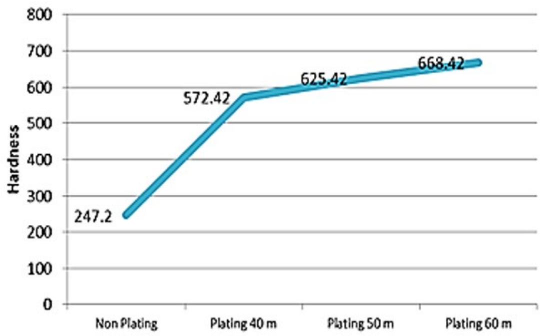

Fig. 3. Hardness nickel plating materials.

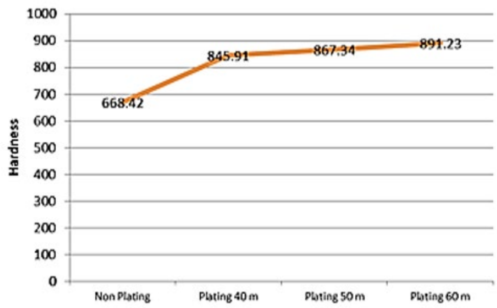

Fig. 4. Hardness chrome plating materials.

To determine the structure and morphology of the test material, SEM-EDS testing was carried out as shown in Figs. 5 and 6, and XRF testing. Based on these tests, the results of the nickel and chrome layers on the surface of the test material can be determined.

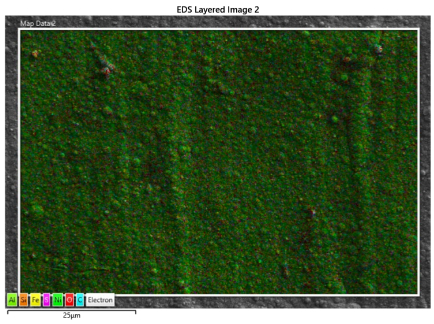

Fig. 5. SEM-EDS Test results for nickel plating material.

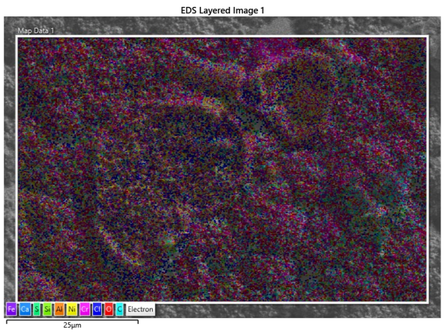

Fig. 6. SEM-EDS Test results for Ni-Cr plating material.

Based on the SEM-EDS test results, it is known that the electroplating process went well. The surface of the material is evenly coated with nickel, and the chemical composition in Table 1 shows that 82.07% of the nickel element is deposited, and the other elements consist of -other elements. Furthermore, in Fig. 6, the surface of the material coated with nickel is coated again with a second coating process using chrome elements, coated evenly, where the chemical composition in Table 2 shows that 43.0% of chrome elements are deposited, 17.7% of nickel elements, and other elements.

Table 1. Structure of chemical composition of nickel plating material.

Element	Weight %	σ
Ni	82.7	0.2
C	13.4	0.2
O	3.1	0.1
Al	0.4	0.1
S	0.3	0.1
Si	0.2	0.0
Fe	0.0	0.5

Table 2. Structure of chemical composition of Ni-Cr plating material.

Element	Weight %	σ
Cr	43.0	1.0
Ni	17.7	0.4
C	14.6	0.4
O	10.2	0.2
Fe	6.5	0.6
Cl	6.4	0.1
Si	0.5	0.0
Ca	0.4	0.1
Al	0.4	0.0
S	0.2	0.0

The layers of nickel and chrome coated on the material, as shown in the SEM-EDS results, improve the quality of the material, namely its hardness, strength increases, and corrosion resistance also increases. The potential aggressiveness of corrosion will decrease because the test material has been coated with Ni-Cr. Thus, the test material becomes passive because it is not in direct contact with the environment so it is protected from corrosion [29-30].

5. Conclusion

Based on the research results, it is known that coating using nickel and chrome increases the hardness and material. The initial hardness value of the material is 247.2 HRV. After being coated with nickel for 40, 50, and 60 minutes, the hardness value increased to 572.42, 625.42, and 668.42 HRV, respectively. Next, the coating was carried out using chrome with the same coating time, increasing the hardness to 845.91, 867.34, and 891.23 HRV, respectively. Based on the SEM-EDS test, the surface is coated with Ni-Cr elements well and evenly so that the surface becomes passive because it is not in direct contact with the environment, namely bioethanol. The fuel is mixed with gasoline, and the material will be protected from corrosion.

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