Development Method for Nickel Electroplating on Aluminium

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Abstract. Aluminum is important material due to high strength/weight ratio. Nickel plating is proposed on aluminium for the purpose of improving wear resistance, tribological properties, surface hardness, and decorative appearance. There are number of difficulties when electroplating nickel on aluminium is expected. The aluminium is amphoteric are soluble in both alkaline and acid. The potential difference between aluminium and nickel can affect the deposition reaction due to the diameter and the crystal lattice structure of both different atoms. This study developed nickel electroplating on aluminium. Copper and zinc are used as intermediate deposits and final pretreatment coating performed with nickel plating. Interface layers that have been produced are investigated to determine the quality of the nickel layer is obtained.

1. Introduction
Some basic characteristics of aluminum that make it favorite for application are low density, and high strength/weight ratio. Plating on aluminum is increasingly important because of the possibility of combining the low density of aluminium with the functional properties of the deposit. Good results can be obtained with a suitable combination of metal and process. As an example it could be interesting to add wear resistance, hardness and corrosion protection to aluminum [1]. The maximum stress for aluminum is increased dramatically by nickel coating [2].

The processes for plating on aluminum can be done by electrolytic plating. Reactions taking place as a result of electrochemical action with an external power supply is used [1].

The nickel electroplating on steel is already well establish. All parameter such as current density, bath concentration, bath solution volume and electroplating time to obtain good and desirable result were found³ but not with electroplating of nickel on aluminium. The difficulties to be considered when electroplating of nickel on aluminum: Aluminum is amphoteric which mean it is dissolved in both acid and alkali, the position of aluminum in the electromotive scale, immersion deposits of nickel and chemical attack of the aluminum substrate will occur[4]. Due to difficulty in nickel electroplating on aluminium, several other surface treatment method are applied such as Anodizind [5] and more even by laser alloying of aluminum with electrodeposited nickel [6].
Other technique such as electroless nickel plating is known to have a major problem of sudden bath decomposition [7]. Development of combining layer in electroplating was introduce to increase the thickness of nickel layer for severe corrosion service. Single-layer bright nickel coatings are only specified for mild corrosion service [8].

This research develop nickel electroplating on aluminum by applying multi layer interface of zinc and copper that can be as consideration to improve the quality aluminium.

2. Experimental

Two methods of nickel plating on aluminum were developed in this research. The first method was by zinc plating and continued with final nickel plating. The second method was by serial plating of zinc, copper and finally by nickel plating. Aluminum plate material which is used in this research be examined the composition using X-ray Fluorens (XRF) as shown in Table 1.

| Elements | Al  | Ag  | Fe   | Cu   | Ni  | Ca  | Mn  | Sc  |
|----------|-----|-----|------|------|-----|-----|-----|-----|
| Composition | 95.1 | 2.57 | 0.941 | 0.247 | 0.198 | 0.17 | 0.17 | 0.12 |

Cleaning is done by a series of solvents, alkalis, and pickles. Preparation of aluminum and special alloys as aluminum exposed to air is always covered by a dense oxide layer that must be removed before the parts can be layered. Furthermore, deoxidized parts must be protected during transfer, to avoid reoxidation of the aluminum surface that is very active.

For the first method, The zinc layer was introduce by using ion exchange plating technique. The ion-exchange plating process is based on oxidation (dissolution) of the aluminum substrate whereby electrons are freed so that a reduction (deposition) of another metal coming from the aqueous solution is possible. The layers deposited are thin, because the deposition stops, when the aluminum is all covered and can no more supply electrons by oxidation. The processes are used as a pretreatment to plating (electrolytic and electroless). The electrolytic plating processes often require this pretreatment to improve the adhesion and to avoid the aluminum from getting dissolved in the plating bath, because aluminum is amphoteric. The solution of sodium hydroxide and zinc oxide was prepared for this purpose with pH 9.4. The sample was immersed in 30 second. The next process is nickel plating by using watts solution.

For the second method, the aluminum was initially plating by zinc plating the same as first method then continued with copper bright plating and finally by nickel plating. Both copper bright and nickel plating were electroplating method. The solution for copper bright was copper sulphate and H₂SO₄ and the nickel plating by using watts solution.

The physical result of serial plating was observed at the cross section of the specimens by using metallurgical microscope.

3. Result and discussion

The result for the first method can be seen in Figure 2. The nickel plating is found attached well to the surface of the aluminum without distance as compares to Figure 1. The zinc plating is success to protect the aluminum surface as indicate that the serial plating of zinc and nickel are attached well without distance in the interface. In this case the function of zinc plating is to protect the aluminum surfaces during processing. The zinc deposit protects aluminum against reoxidation from atmospheric
exposure and redissolves in the electroless nickel solution, exposing an oxide-free aluminum substrate, upon which nickel deposits form adherent coatings.

The result from second method of nickel plating on aluminum can be seen in Figure 3. The aluminum is plated with serial plating of zinc, copper and finally nickel plating. Similar result is obtained where both copper and nickel are found well attached without distance observed between the interfaces.

![Figure 1](image1.png)

**Figure 1.** Distance between the aluminum surface with nickel coating due to amphoteric of aluminum to electroplating solution

![Figure 2](image2.png)

**Figure 2.** Photomicrograph of cross section of serial plating of zinc and nickel on aluminum. The zinc plating is very thin and can not observed in this scale of magnification

If the result from Figure 2 and Figure 3 are compared, it is found that the nickel plating obtained by first method have thicker result for nickel plating. This is yield to better surface hardness.

With the success of nickel electroplating method that is develop in this research, future development should be encourage such as electroplating line flexible control method [9]. The method that is develop in this research also possible to be applied in application to solar cell concepts [10].
future work The effect of nickel coating developed in this work to the microhardness of aluminium will be investigated [11]

Figure 3. Photomicrograph of cross section of serial plating of zinc copper on aluminum. The Zinc coating is very thin and can not observed in this scale of magnification

4. Conclusion

The aluminum can be nickel plated by pretreatment the surface with zinc plating continued with nickel plating. Other alternative is by serial plating with zinc, copper and finally by nickel plating. The hardness and tensile strength will be reported in separated report regarding mechanical properties of nickel electroplating on aluminium.

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