Effect of Metal Coatings on Mechanical Properties of Aluminium Alloy

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Abstract. This investigation mainly targeted on study of hardness and tensile properties of Al 7075 with different metal coatings like Nickel, Zinc and cadmium. Coating of these metals on Al 7075 is successfully achieved by time dependent electroplating method for different thicknesses of 10, 15 and 20 Microns. These metal coated Al-7075 specimens were tested for hardness and tensile properties according to the ASTM standards. It's found that Nickel coated alloy shows excellent hardness and tensile properties compared to Zinc and Cadmium coated alloys. 20 µm Nickel coated alloy exhibits highest hardness number of 102 HRB and Maximum Tensile Strength of 603 MPa than Zinc and Cadmium coated alloy. The microstructural studies authenticated that the coating of Nickel, zinc and cadmium on Al 7075 is homogeneous.

Keywords: Al7075, Hardness, Tensile Strength.
PACS: 81.20.Ev, 81.40.Pq

INTRODUCTION

Aluminium and its alloy are widely used in the field of automobile and aerospace industries application [9] due to their outstanding properties including high strength to weight ratio, thermal properties good mach inability [11] better corrosion resistance etc., Numerous coatings [1] on aluminium alloys 7075-T6 have been investigated of late to enhance corrosion resistance [15], improving mechanical properties [5], Fracture toughness, surface hardness and tribological properties [2]. Fatigue cracks would be instated at macroscopic defects due to machining scratches and also at corrosion spots hence fracture toughness [6] also needs to be evaluated specially for aerodynamic applications. Fracture based design is specially used to estimate the life of a component. On the other hand improving on the mechanical properties [13] due to a small change in the density would also be desirable in some circumstances. Aluminium alloy does not show good wear resistant [7] hence a coating is probably a choice to improve the same. Improving the surface properties [14] of the alloy would enhance the wear property of the alloy. Among the various coatings to mention a few, Zinc coating [8] on alluminium alloy shoes good adherence and reduces wear significantly [1]. TiN coated aluminium alloy increases hardness [10] significantly and also improves the fatigue life of the material due to residual compressive stress induced during the coating process [2].Ni coated Aluminium alloy shower superior tribological properties [12] due to good adhering of Ni with aluminium alloy with sufficient strength as well as good corrosion resistance [3-8]. Cadmimum coated alluminimu alloy shows excellent corrosion resistance and increases surface hardness of the material [9]. It is very clear that each of these coatings affects the properties of the Aluminium alloy, hence it is important to understand the varying properties with different coatings on the AL7075-T6 alloy.

COMPOSITION OF AL7075 ALLOY

TABLE (1) Material composition of Al 7075 alloy

Elements	Zn	Mg	Cu	Fe	Si	Ti	Mn	Cr	Sn	Ni &Pb	Al

% of wt	5.9	2.8	1.9	0.19	0.09	0.02	0.03	0.2	0.02	<0.01	Remainder

SPECIMEN PREPARATION AND PLAN OF EXPERIMENTS

The Al7075 alloy was coated with Cadmium ,Nikel and Zinc with each 3different thickness to study it mechanical properties and surface hardness. The preparation of these coated specimens are as below.

Cadmium Coating (Electroplating Cadmium Coating Process)

The Al7075 alloy was cleaned thoroughly by using bases and acids to give good adhesive surface followed by rinsing with water to remove the chemicals. The acid removes any scaling on the surface and bases remove the oil from the surface. Electrolyte solution consisting of cadmium (alkaline cyanide) salts was used in electro deposition process to cote the alloy. Cadmium is deposited in the cathode material (Al7075 alloy) when current was passed. The alloy was removed and finished with an anti-oxidation chemical (sodium, dichromate) and is rinsed with pure water to remove stains, degreased and De-rusted then passivated.

Nickel Coating (Electroless Ni coating Process)

The specimens to be coated with nickel are washed by a series of chemicals such as bases and acids to import better adhesion. Every chemical treatment is followed with water rinsing to eliminate the chemicals that sticks to the surface of base metal. Degreasing eliminates oil and grease from surface and acid washing removes scaling. This process includes dissolution of one anode electrode and the coating of metallic Nickel on the other cathode electrode. Direct current is imposed between the anode and cathode. Conductivity between both the electrodes is employed by an aqueous solution of Nickel salts. When Nickel salts were dissipates in water, the Nickel is available in solution as divalent, positively charged Ni++ ions. When current passes, divalent Nickel ions get react with two electrons (2e-) and are changes to metallic Nickel at the cathode electrode. The reverse happens at the anode end where metallic Nickel evaporates to form divalent ions. Since the Nickel ions ejected at the cathode end are reload by the Nickel ions established at the anode end. Activation is react with a poor acid etch or nickel strike. After the coating succeeding, coated material is washed with trisodium phosphate anti-oxidation or trisodium phosphate anti-tarnish chemicals and rinsed with pure water to prevent undesirable stains.

Degreasing : Degreased in Steelex K-20 Solution
Anodic cleaning : Anodic cleaned in Growel solution
Activation : Activated in H_2SO_4 based solution.
Pre heating : Pre heated in ELN based solution (Phosphorous 6-9% content).
Finally part is dipped in ARMOR chemical.
Passivation : Passivated in Chromate solution and water swilled twice.

Zinc Coating Process

The aluminium 7075 alloy should clean for any dirt and foreign materials. Zinc coating was performed by electro plating Technique. The same is then made chemically inactive by dipping in chromatic solution and washed with running water to clean the traces of chemical on surface.

TENSILE TEST AND HARDNESS TEST

ASTM E8 Standards were followed for the tensile tests of the specimen. The specimen dimensions are as shown in the figure below. Rockwell hardness tests were conducted with the use of steel indenter (1/16 inch) with a 10kgf minor load and 140 kgf major load for a period of 20 seconds.

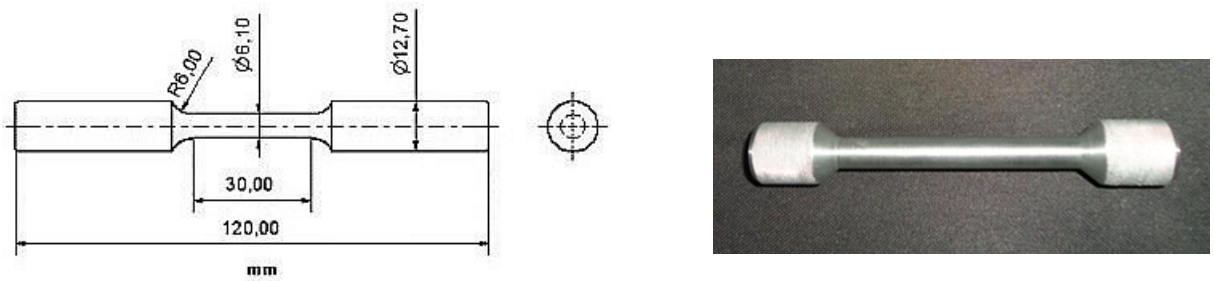
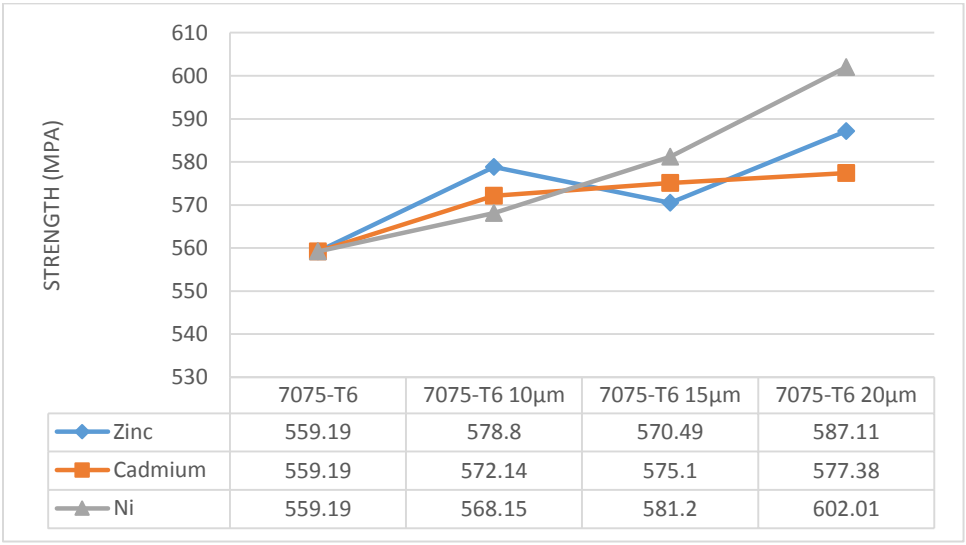


FIGURE 1. Tensile Test Specimen

RESULTS AND DISCUSSION

Tensile Strength and Hardness

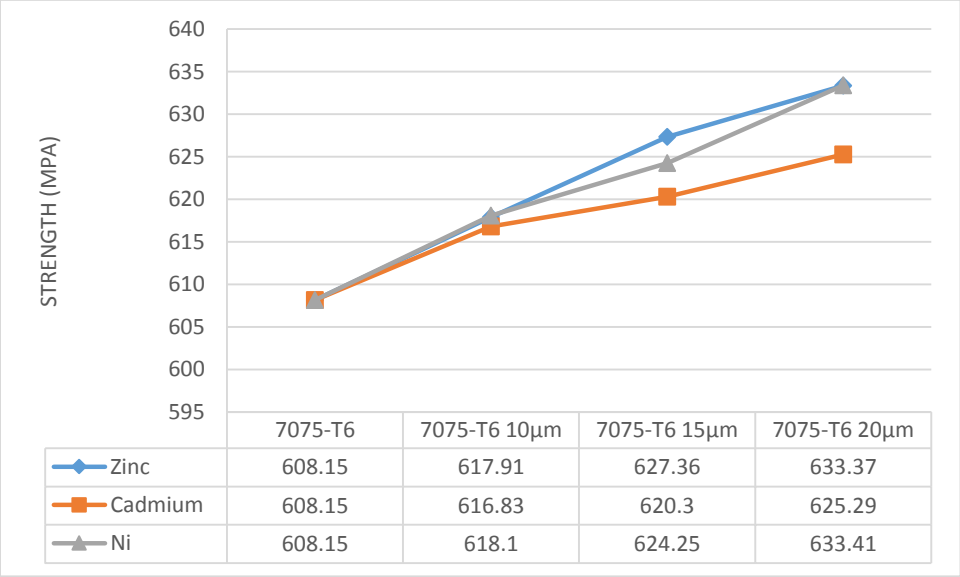
The test results are tabulated in the figure below. The figure below indicates that the Alloy Al7075-T6 coated with Ni 20 µm have the highest yield strength compared to all the other coatings. Also It depicts that with the increase in the coating thickness there is a appreciable increase in the yield strength. It is also observed that the coating shows progressive delamination at maximum loads indicating a plastic deformation.



	7075-T6	7075-T6 10µm	7075-T6 15µm	7075-T6 20µm
Zinc	559.19	578.8	570.49	587.11
Cadmium	559.19	572.14	575.1	577.38
Ni	559.19	568.15	581.2	602.01

FIGURE 2. Yield Strength Variation

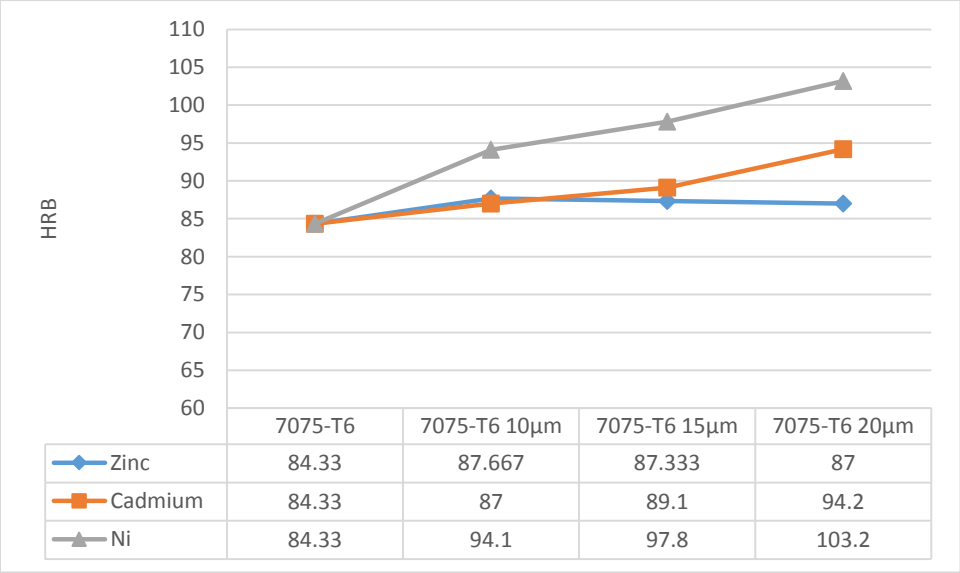
The figure below indicates that the Alloy Al7075-T6 coated with Ni 20 µm and Zinc 20µm more or less have the highest ultimate strength compared to all the other coatings. Also It depicts that with the increase in the coating thickness there is a appreciable increase in the ultimate strength.



	7075-T6	7075-T6 10µm	7075-T6 15µm	7075-T6 20µm
Zinc	608.15	617.91	627.36	633.37
Cadmium	608.15	616.83	620.3	625.29
Ni	608.15	618.1	624.25	633.41

FIGURE 3. Ultimate Strength

The figure below indicates that the Alloy Al7075-T6 coated with Ni 20 µm have the highest hardness compared to all the other coatings. Also It depicts that with the increase in the coating thickness there is a appreciable increase in the Hardness.



	7075-T6	7075-T6 10µm	7075-T6 15µm	7075-T6 20µm
Zinc	84.33	87.667	87.333	87
Cadmium	84.33	87	89.1	94.2
Ni	84.33	94.1	97.8	103.2

FIGURE 4. Hardness Number

Macrostructural analysis

Optical microscopy analysis of the electroplated specimens were carried out successfully and metallic coating that the layer formed by cadmium, nickel and zinc was uniform throughout. Adherent and thickness measure up to 10µ, 15µ, and 20µ.There was a small amount of cadmium coatingpeel out on aluminium for 20µ thickness, but the strength of the cadmium coated aluminium is not affected.This macrostructural study also confirms that there are no traces of chemical reaction either by coated material or a coating process with the base metal.

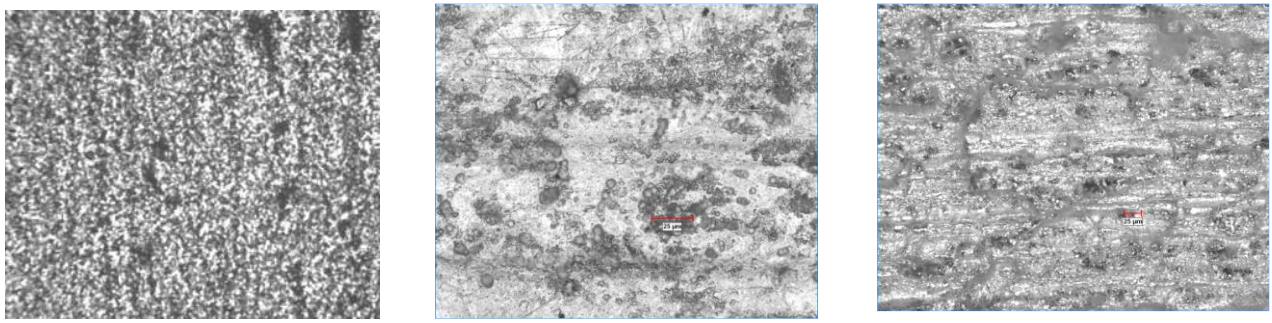


FIGURE 5.*Microstructure of Cadmium coated specimens (Pure 7075T-6 µm, 15 µm and 20 µm)*

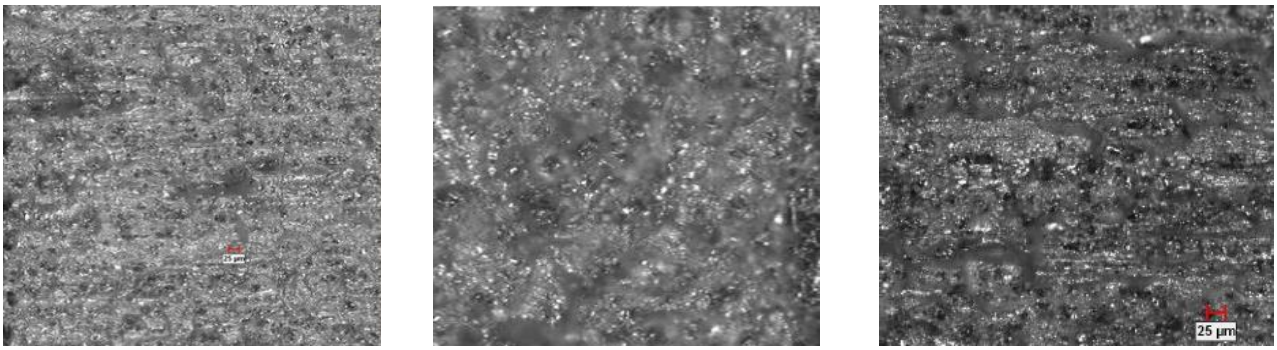


FIGURE 6. *Microstructure of Nickel coated specimens (10µm, 15 µm and 20 µm)*

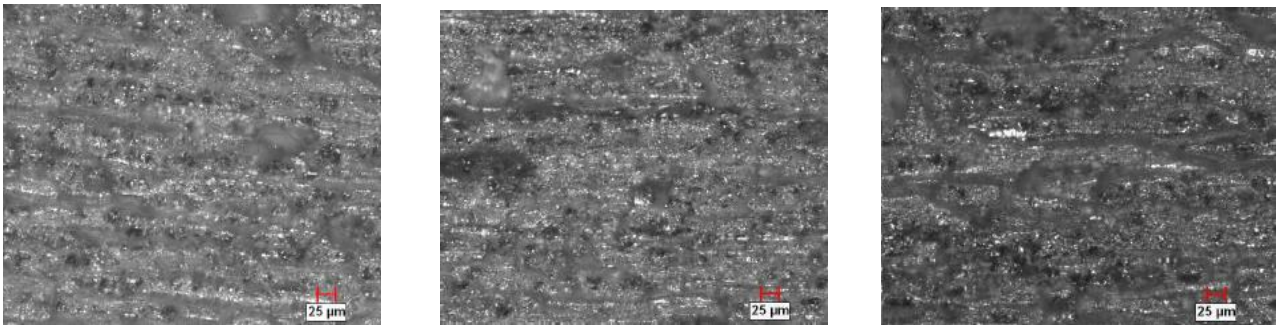


FIGURE 7. *Microstructure of Zinc coated specimens (10µm, 15 µm and 20 µm)*

CONCLUSION:

All the aluminium specimens were successfully coated with cadmium, zinc and nickel by electro plating process successfully for different thickness of 10µ, 15µ, and 20µ respectively. The 20µ nickel coated aluminium specimen showed a better hardness of 103.2HRB against all other coatings of different thickness. Specimen with nickel of 20 µ coated specimen exhibited highest yield strength of 602.01Mpa, and coating of 20µ zinc on a aluminium specimen had improved its ultimate strength by 633.37Mpa against its original value of 608Mpa.Misroctrural observations revealed that the coating of all metals on aluminium specimen were uniform and no traces of any other chemical reactions.

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