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Research Article

Investigations on Tensile Strength of Aluminium and Nickel Coated Aluminum

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Abstract

Electro less deposition is an autocatalytic chemical technique to deposit a coating of metal on a work piece with the presence of a reducing agent. Electro less nickel coating has high advantages in electroplating. In this work the changing structure of nickel deposits on aluminum and its alloys at the early stage of electro less nickel deposition using sodium hypophosphite ion used as reducing agent which has been studied. The behavior of nickel coating on tensile behaviour of aluminium is investigated using experimental and as well as numerical methods .In this case FEM software ANSYS 14.0 is used for the numerical analysis for compare to experimental investigations. The experimental investigations were also validated by numerical analysis.

Keywords: *Specimen, Electroless Nickel coating, Stress-strain curve, FEA,*

1. Introduction

Electroless nickel–phosphorus deposition is an established industrial practice as a protective and decorative coating in various industries due to its superior corrosion and wear resistance, excellent uniformity, wide range of thickness as well as mechanical and physical properties. More research has carried out on the characterization of the electro less nickel coating process.

Corrosion properties of electroless Ni–P deposition depend mainly on phosphorus content and the corresponding structural due to internal stress within the Ni–P deposited layer are affected by the substrate pretreatment method. It is always very tough to plate aluminium and its alloys with any metal or metallic based surface coating, either by a cathodic or electroless deposition is due to the tenacious oxide layer present on aluminium. Aluminium and its alloys have excess affinity for oxygen which results in a rapidly growing thin oxide film on freshly cleaned and etched aluminium surfaces. It is tough to plate aluminium substrates covered with such an oxide film with good adhesion.

An appropriate pre-treatment process is an essential surface conditioning step before any plating is carried out. The satisfactory and practical method available for aluminium preparation prior to further deposition is called zincating. The zincating process always consists of double dip into the zincates solution to produce a uniform layer of zinc on the aluminium surface. The double zincation protects the aluminium substrate from reoxidation until it is ready to be electro less plated with nickel, followed by further deposition. Sodium hypophosphite used as reducing agent, the deposited layer always contains phosphorus in addition to nickel. The metal reduction of nickel is very complexity, as the kinetics of the reduction reaction governs not only the rate of metal deposition also the chemical and physical properties of the electro less nickel deposit.

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2. Literature Survey

An autocatalytic nickel deposition initially was developed using a sodium hypophosphite bath (Brenner, et al, 1946). There are numerous parameters affecting the electroless nickel process as suggested by (Baudrand, et al, 1999). Temperature, pH, nickel ion concentration, reducing agent concentration, the loading in the bath and agitation affect the nickel deposition rate. concluded that the nickel ion is catalytically reduced by means of the active atomic hydrogen with simultaneous formation of orthophosphite and hydrogen ions (Gutzeit, et al, 1959). The electro less nickel deposition bath is known to have a major problem of sudden bath decomposition, so that results in an increasing the operating cost also the generation of environmental hazardous waste (Cheonga, et al, 2004). Investigations discussed that atomic hydrogen is released as a result of the catalytic dehydrogenation of hypophosphite molecules disturbed at the surface which then reduce nickel at the catalyst surface. It is concluded that electroless nickel deposition therefore cannot be solely chemical but is controlled by an electrochemical mechanism. The phosphorus content during electroless nickel deposition controls the microstructure of the coating. Previous research on autocatalytic electroless nickel reports that coatings with lower phosphorus content are crystalline and have superior wear resistance while those with higher phosphorus content are amorphous and have superior corrosion resistance (Gorbunova, et al, 1963). An electro less Nickel-Cobalt-Phosphorus electrolyte solution containing sodium citrate and lactic acid as complexing agents in order to get a relatively high deposition rate (Aly and Younan, et al, 2003).Coatings can be obtained for desired properties by selecting the correct composition of the coating alloy, composite and metallic to suitable specific requirements (Agarwala, et al, 2003). Nickel–Phosphorus deposition is very closely related to the dissolution of the zincating layer, then followed by progressive nickel nucleation (Enam Khan, et al, 2007).

2.1 Problem Definition

The present problem is to investigate the influence of nickel coating on tensile behavior of aluminium. Both experimental and numerical investigations are carried out for the same.

3. Methodology

Aluminium alloys were used as samples for zincating and electroless nickel deposition. These aluminium specimen samples were prepared for the following dimensions: 30 mm x10.54 mm x2.02 mm. Two samples of aluminium were prepared, one with nickel coated and another without coated. The bath for electroless plating was prepared as per the chemical composition given in table1. Prior to plating specimen, specimen was immersed in NoaH solution to remove the oxide layer. The specimen is then the exposed to nitric acid solution to remove impurities like silicon and magnesium. This process of removing impurities is called desmutting. Zincating was carried out to protect the surface to be coated. Fig.1 gives the experimental setup used for our work.

Table.1 The bath used for metallization of aluminium had the following chemicals

S..No	Chemical composition	Weight
1	Nickel Sulphate-0.12M	35gr/L
2	Sodium acetate-0.6M	50g/L
3	Sodium Hypo phosphate-0.32M	28g/L
4	pH	4.8
5	Temperature	70^0C

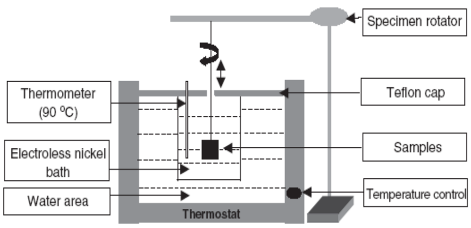

Fig.1 Experimental apparatus of electroless nickel plating

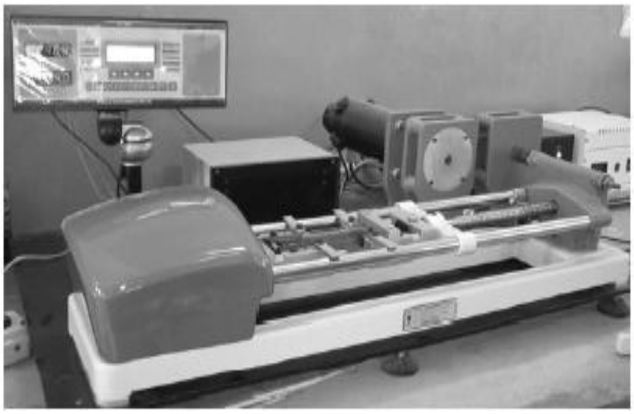

Fig.2 Electronic Tensiometer

Fig.3 Aluminium with and without nickel coated

Electronic Tensiometer, shown in fig.2 was used to study the tensile behaviours of nickel coated aluminium and pure aluminium. Fig.3 presents the specimen used for the study. Tension test was conducted and the load vs deformation was noted down.

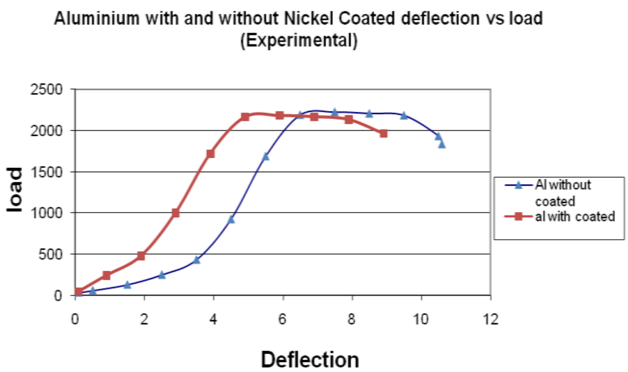

Fig.4 Load vs deformation of aluminium and nickel coated aluminium

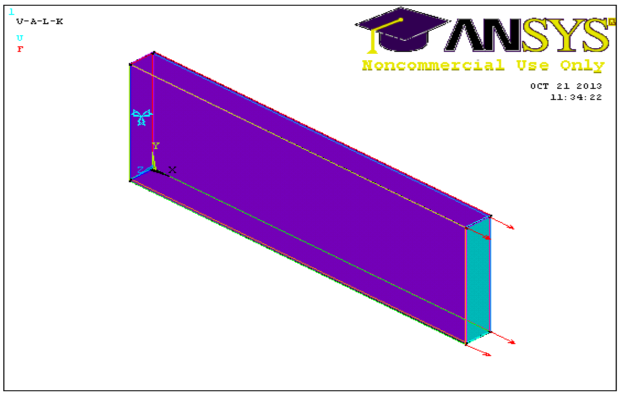

Fig.5 Boundary condition and loading of Aluminium with nickel Coated

The same is presented in fig.4. In Finite Element Analysis, using ANSYS was carried out to study the tensile behaviors of aluminium and nickel coated aluminium. In this case, aluminium is used as base plate and nickel used as coated one. Fig.5 presents the Boundary conditions and loading conditions of FE Analysis. Fig.6 gives the finite element meshing of the sample. Fig.7 gives the displacement result of the nickel coated aluminum. After performing uniaxial tensile load simulation using ANSYS, stress-strain curve for coated and uncoated specimen are plotted.

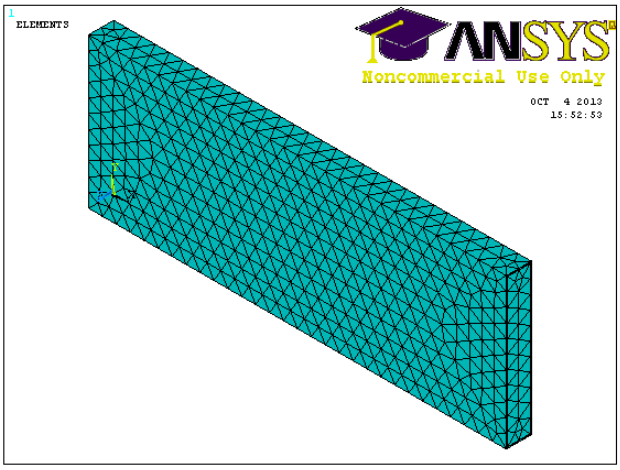

Fig.6 ANSYS Meshing of Aluminium and with nickel coated

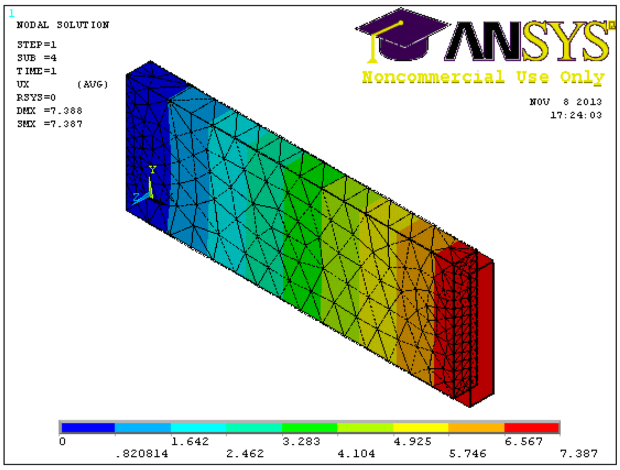

Fig.7 ANSYS displacement of Aluminium and with nickel coated

4. Results and discussion

4.1 Stress-strain behavior studies

The Experimental and analysis stress-strain behaviors of the aluminium and nickel coated aluminium are shown in figures 8-10.

From fig.8 it is showed that the coating of Nickel affects the stress strain behavior of aluminium. Upto the elastic limit, though there is no major difference in the value of yield stress but a significant difference is visible in the stress strain curve. This is due to the high ductility of Al metals. The different in the stress stain behaviors are insignificant from elastic limit to plastic instability. There is minor change in the values of ultimate stress and failure stress if the aluminium is coated with nickel. The uncoated aluminium shows high percentage of elongation than the coated one.

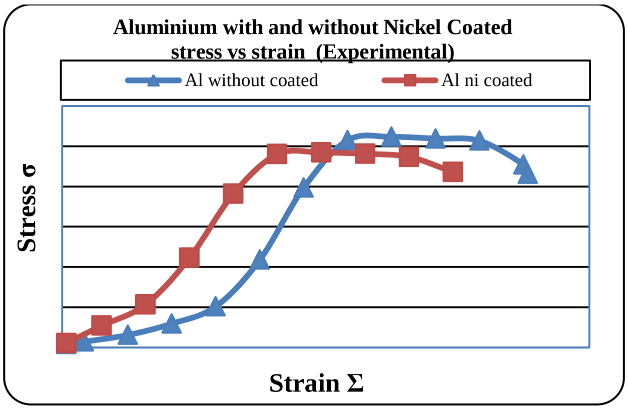

Fig.8 Stress strain curve for Aluminium with and without coated Experimental

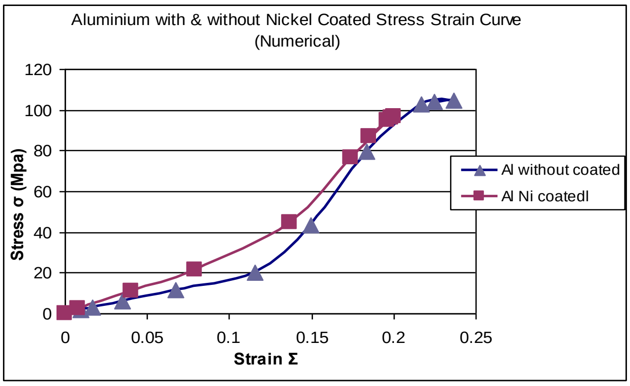

Fig.9 Stress strain curve for aluminium with and without coated numerical

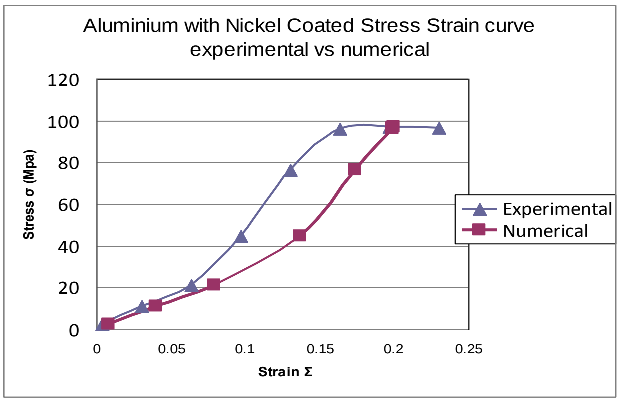

Fig.10 Stress strain curve for aluminium on nickel experimental vs numerical

From fig.9 gives the stress strain behavior of coated and uncoated aluminium by using finite element method. The explanation given for experimental analysis stands good for finite element analysis.

Fig.10 compares the stress strain behavior of nickel coated aluminum using experimental analysis and finite element analysis. Both experimental and numerical comes or similar upto elastic limit. But small change is seen from elastic limit to plastic instability. This is due to the nature of coating in the experimental analysis.

Conclusions

Influence of nickel coating on mild steel with respect to tensile property is studied.

The study includes experimental as well as numerical methods. There are no major differences found in the stress behaviors of coated and uncoated specimens.

But there is minor difference in the strain due to the material properties of aluminium and nickel. Experimental study was later validated with finite element Analysis.

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