# HIGH SPEED NICKEL PLATING ON DIFFICULT TO PLATE METAL (ALUMINIUM)

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# HIGH SPEED NICKEL PLATING ON DIFFICULT TO PLATE METAL (ALUMINIUM)

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A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Materials)

**Faculty of Mechanical Engineering**
**Universiti Teknologi Malaysia**

**NOVEMBER 2010**

***For my beloved mother, father,***
***family and all my friends***

# ACKNOWLEDGEMENT

In the name of Allah, the Most Merciful and Most Beneficent

It is with the deepest senses of gratitude I acknowledge that Almighty Allah gave me the strength and ability to complete this research work and write this thesis. I would like to express my sincere thanks to Dr. M. Sakhawat Hussain, my supervisor, for allowing me to use his award winning equipment for high speed plating and for all his guidance and encouragement that he provided in the course of this research work at Universiti Teknologi Malaysia, Skudai. His time, patience, consideration and also his creative ideas are greatly appreciated. I would also like to thanks all technicians for their help during my experiment. Their careful amendments and creative ideas are greatly appreciated. In addition, I would also like to thank to all my friends who sacrificed a lot of their time to help me with my research. Last but not least, I would like to thank my parents and my family for their love and encouragements.

# ABSTRACT

Aluminium has been widely used in many field of application due to the low density, sensitive to corrosion, high mechanical strength and ease of fabrication. Plating of metal on aluminium is complex and difficult because aluminium always reacts with air to form oxide. It is difficult to obtain a good adhesive property on the aluminium surface. Thus, to plate metal on the aluminium, oxide layer must be eliminated by using an intermediate pre-treatment. However, this process involves several steps and even then the level of addition between the plated metal and the aluminium part is poor. The object of this project was to investigate the possibility of plating nickel directly on aluminium surface without any pre-treatment process, investigating the level adhesion between the deposited nickel and the aluminium base by high speed electroplating technique and also to investigate the effect of current density, temperature and different type of solution on weight of plated sample, thickness of plated sample and rate of deposition. The level adhesion of the nickel coating was determined qualitatively by using Adhesion Testing while morphology and thicknesses of Ni plated was studied using Scanning Electron Microscopy (SEM). It was found that the level of adhesion between nickel and aluminium became low at current density above 1.0 $A/cm^2$ and Ni plated was found to peel off easily. Besides, by increasing the current density and temperature the weight and thickness of Ni plated increase and sulphate based Ni solution gave much higher rate of deposition compared to the traditional Watt's based solution by increasing the current density and temperature.

# ABSTRAK

Aluminium telah banyak digunakan dalam pelbagai bidang disebabkan sifat ketumpatannya yang rendah, kekuatan mekanik yang tinggi dan mudah untuk dibentuk. Penyaduran logam pada aluminium adalah sangat rumit dan sukar kerana aluminium .sentiasa bertindak balas dengan udara untuk membentuk oksida. Ini menyebabkan sukar untuk mendapatkan hasil lekatan yang baik pada permukaan aluminium. Oleh itu, untuk menyadur logam pada aluminium, lapisan oksida perlu dibuang dengan menggunakan pra-rawatan lanjutan. Namun begitu, proses ini melibatkan beberapa langkah dan tahap lekatan antara logam dan aluminium tidak begitu memuaskan. Objektif projek ini adalah untuk menyiasat kebolehan penyaduran nikel secara lansung pada permukaan aluminium tanpa melakukan proses pra-rawatan, menyiasat tahap lekatan antara nikel dan aluminium dengan menggunakan teknik "*High Speed Electroplating*" dan juga untuk menyiasat pengaruh ketumpatan arus, suhu dan jenis larutan pada berat, ketebalan, dan kadar penyaduran yang dihasilkan. Tahap lekatan saduran nikel ditentukan dengan menggunkan ujian perlekatan manakala morfologi dan ketebalan saduran nikel ditentukan dengan SEM. Didapati bahawa lekatan antara nikel dan aluminium menjadi rendah pada ketumpatan arus melebihi 1.0 $A/cm^2$ dan saduran nikel yang dihasilkan mudah tertanggal. Selain itu, dengan pertambahan ketumpatan arus dan suhu, berat dan ketebalan saduran nickel juga bertambah. Larutan "*Sulphate based Ni*" memberikan kadar penyaduran yang tinggi berbanding dengan larutan "*Watt's*" dengan pertambahan ketumpatan arus dan suhu.

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| Al | - | Aluminium |
| ASTM | - | American Society for Testing and Materials |
| $CuAl_2$ | - | Cuprum Alumina |
| $CuMgAl_2$ | - | Cuprum Magnesium Alumina |
| EDAX | - | Energy Dispersive Spectroscopy |
| $FeAl_3$ | - | Ferum Alumina |
| Mg | - | Magnesium |
| $Mg_2Al_3$ | - | Magnesium II Alumina |
| $MgZn_2$ | - | Magnesium Zinc |
| $MnAl_6$ | - | Manganese Alumina |
| Ni | - | Nickel |
| $NiAl_3$ | - | Nickel Alumina |
| SEM | - | Scanning Electron Microscope |
| Si | - | Silicon |
| Zn | - | Zinc |

# LIST OF SYMBOLS

| | | |
|---|---|---|
| $a_M^{Z+}$ | - | Bulk activity |
| D | - | Diffusion of Coefficient of $M^{Z+}$ |
| $e^-$ | - | Electron |
| $i_L$ | - | Limiting Current Density |
| t | - | Transport number |
| V | - | Electrode Potential |
| δ | - | Thickness |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of the Project

The process for nickel plating on aluminum has advanced over the past decade from a rather complicated technology to a very consistent, easily reproducible procedure (George and Chadd, 2009). As a consequence of the continuous improvement in processing techniques, nickel plating is being relied upon more as a finish of choice by design engineers looking for lightweight, high strength materials in the manufacture of their products (George and Chadd, 2009; Mest, 2009). While aluminum has a good strength-to-weight ratio and excellent machinability, nickel plating can extend the ability of aluminum to function in applications where it could not be considered otherwise. Friction, wear and appearance are greatly enhanced by applying specific electroplating nickel coatings. For electronics applications, high phosphorous electroplating nickel can provide non-magnetic properties, corrosion resistance and extended wear.

The plating of metals on aluminium is a complex and highly developed (Satee and Schaumburg, 1980; Cooper et al., 1961; Bornhauser et al., 1932). For the most part, when it is desired to coated nickel on aluminium, the practice has been first to plate the aluminium with an intermediate layer of copper (Satee and Schaumburg, 1980). The nickel coating is then superimposed on the copper film, after which the object may be further processed by applying an outer chromium coating, if desired. In other processes the aluminium is first dipped in a cadmium plating bath, after which the article is electroplated or otherwise coated with such metal as copper, nickel, tin or any of other various metals as desired (Satee and Schaumburg, 1980; Cooper et al., 1961). In other processing techniques known as zincate process and the stannate process, a thin coating of zinc or tin is applied to the aluminium prior to the subsequent electrolytic deposition of other coating metals. But, these processes always require a copper or a bronze strike to prevent dissolution of the zinc or tin in the nickel bath (Kampert and Burell, 1976).

This project relates to a process for depositing a film or coating of nickel directly on articles of aluminium without the need to preplate or otherwise to coat with an intermediate layer such as copper, zinc or cadmium.

## 1.2 Problem Statement

Generally, electroplating method nickel on aluminium has been developed, but through this method involves several steps for plating nickel on aluminium by using an intermediate pre-treatment process and the deposition of a zincate layer (Miller, 1972). This is because oxide layer forms almost instantaneously on the aluminium surface. Because of the presence of oxide layer on aluminium surface, it is difficult to obtain a good adhesive property on the aluminium surface (Topelian and Newark, 1958; Kampert and Burell, 1976). Beside, the level addition between

the nickel plating and the aluminium part is poor (Frasch, 1941). Because of this problem the high speed plating method is chose to plate the nickel on aluminium.

## 1.3 Objectives

The main objective of this research is to find out the possibility of nickel plating directly on aluminium surface without any pre-treatment process. The study also includes investigating the level adhesion between nickel and aluminium by high speed electroplating technique. The third objective is to investigate the effect of current density and temperature on weight and thickness of nickel plating layer. The fourth objective is to investigate the effect different type of solution on deposition rate of nickel plated.

## 1.4 Scope of the Project

This project consists of three main tasks which include:

1. Deposition of nickel surface finish. The deposition of Ni will be conducted by high speed electroplating process on aluminium substrate.
2. The selection and determination of nickel plating parameters and also to design the experiment for high speed nickel electroplating process on aluminium.
3. Characterize the level of adhesion between nickel and aluminium and the thickness of Ni plated.

## 1.5 Structure of Thesis

The thesis comprise of six chapters. The first chapter is the introduction, which clearly define the objective and scope of this project. Chapter two consists of literature review. In this chapter, it explains the problem of plating on aluminium, conventional plating process on aluminium, high speed electroplating process and lastly the porous anodic aluminium oxide film.

Chapter three is the experimental methodology. In this chapter, a detailed account of materials, setup and procedures followed in the experimental work of this thesis are discussed thoroughly. Chapter four contains the results and discussion obtained from the experimental work conducted. Chapter five included the conclusion drawn based on the results and lastly, the final chapter, chapter six included the recommendations by the author for future work.