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ELECTRODEPOSTION OF NICKEL FLY ASH (Ni-FA) COMPOSITE COATING ON ALUMINUM ALLOY 7075 SUBSTRATE FROM NON-AQUEOUS MEDIA: STUDY EFFECT OF CURRENT DENSITY

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Engineering Materials) (Hons.)

by

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Date : 20 June 2017

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Engineering Materials) (Hons). The member of the supervisory committee are as follow:

…….....

(Dr. Intan Sharhida Binti Othman)

ABSTRAK

Sebatian abu telah dimasukkan ke dalam lapisan nikel untuk dienapkan ke atas aloi aluminium 7075 (AA7075) melalui ketumpatan arus yang berbeza-beza. Tujuan kajian ini adalah bagi menentukan sifat kekerasan dan ketahanan lapisan nikel-abu terbang komposit terhadap kakisan pada permukaan yang telah dienapkan pada AA7075. Larutan etilena glikol pada suhu 40ºC selama 1jam di dalam sel kaca. Pelbagai ketumpatan arus telah digunakan yang itu 0.10A / dm2, 0.15A / dm2, 0.20A / dm2. Proses penyepuhlindapan digunakan untuk mengkaji kesan suhu penyepuhlindapan untuk lapisan abu komposit nikel terbang. Suhu yang digunakan untuk proses penyepuhlindapan adalah 200ºC dan 400ºC. Permukaan morfologi lapisan dianalisis dengan menggunakan mikroskop imbasan electron (SEM) dan komposisi kepekatan abu terbang telah dianalisis dengan menggunakan X-Ray pendafluoran (XRF). Fasa hadir abu terbang bersama-sama dalam matriks nikel dalam salutan komposit pada AA7075 substrat dianalisis dengan menggunakan X-Ray pembelauan (XRD). Morfologi and struktur lapisan nickel menjadi lebih padat dan tumpat seiring dengan peningkatan ketumpatan arus. Sifat kekerasan dan rintangan kakisan bertambah baik seirirng peningkatan ketumpatan arus. Sifat kekerasan meningkat pada suhu 200ºC penyepuhlindapan dan menurun pada suhu 400ºC penyepuhlindapan. Rintangan kakisan lapisan nickel abu terbang menurun selepas process penyepuhlindapan. Untuk mengkaji hubungan antara pelbagai ketumpatan dan suhu penyepuhlindapan ke saiz nickel bijiran, saiz bijiran nikel di kira dan di bandingkan dengan saiz kristal ketumpatan arus yang berlainan suhu dan penyepuhlidapan.

ABSTRACT

The nickel coating with fly ash as reinforcement are electrodeposited on aluminum alloy 7075 (AA7075) with non -aqueous bath via various current density. The aim of this research is to identify the hardness behaviour and corrosion resistance of nickel fly ash composite coating on AA7075 substrate. The electrodeposition process in the glass cell was using an ethylene glycol bath as a solution at temperature 40ºC along 1 hour's electrodeposition period. Various current density have been used which are 0.10A/dm^2, 0.15A/dm^2, 0.20A/dm^2. Annealing process is use to study the effect of annealing temperature to the nickel fly ash composite coating. The temperature that use for annealing process is 200ºC and 400ºC. The Surface morphology of the composite coating is analyzed by using scanning electron microscope (SEM) and concentration of fly ash composition is analyzed by using X-Ray florescence (XRF). The phase present of fly ash together in the nickel matrix in the composite coating on AA7075 substrate is study by using X-Ray diffraction (XRD). Surface morphology and structure of nickel composite coatings become more compact and denser as well as increasing current density. The hardness behaviour and corrosion resistance of coating improved with the increasing of the current density. The hardness behaviour of coating increase after 200ºC annealing temperature and decrease at 400ºC annealing temperature. The corrosion resistance of coating becomes less noble after annealing process. To study the relationship between various current density and annealing temperature toward the nickel grain size, the size of nickel grain is measure and comparing with the crystal size of other different current density and annealing temperature.

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DEDICATION

Only

My beloved father, Yahaya bin Darus

My Appreciated mother Salasiah binti Disa

My adored sister and brother, Muhamad Noorain, Nurul Asyiken, Muhamad Adam, Nurul Dalilah, Nurul Ezzaty and, Muhamad Ikhram Hafeez

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LIST OF ABBREVIATIONS

AA7075	-	Aluminum Alloy 7075
Ni	-	Nickel
FA	-	Fly Ash
Ni-FA	-	Nickel Fly Ash
H^+	-	Hydrogen
SEM	-	Scanning Electron Microscopy
OM	-	Optical Microscopy
XRD	-	X-ray Diffraction
EDX	-	Energy-dispersive X-ray
XRF	-	X-ray Fluorescence
MMCs	-	Metal Matrix Composites
CMCs	-	Ceramic Matrix Composites
PMCs	-	Polymer Matrix Composites
SiC	-	Silicon Carbide
Cr_2O_3	-	Chromium Oxide
TiO_2	-	Titanium Dioxide
Al_2O_3	-	Aluminum Oxide
WC	-	Tungsten Carbide

B_4C	-	Boron Carbide
ZrO_2	-	Zirconium Dioxide
Fe_2O_4	-	Iron Oxide
Bn	-	Boron Nitride
Si	-	Silicon
Fe	-	Iron
Cu	-	Copper
Mn	-	Manganese
Mg	-	Magnesium
CR	-	Chromium
Zn	-	Zinc
Ti	-	Titanium
Al	-	Aluminum
MPa	-	Mega pascal
HV	-	Vickers Hardness
CRTs	-	Cathode Ray Tube
ASTM	-	American Standard Testing Material

CHAPTER 1
INTRODUCTION

1.1 Background of Study

Application of aluminum 7075 (AA 7075) in aerospace and allied field is rising due to its high strength to weight ratio. The most important feature in AA7075 is its density which is one third of steel, so it can replaces many metals structure in many applications. In an aircraft, aluminum is use as structural fastened joints, which may cause wear and fatigue damage. AA7075 also used in automotive component such as for engine pistons part. This part needs a surface treatment to improve the wear resistant to reduce the friction coefficient. This is because piston can work under high temperature and in wearing conditions (Pradeep and Senthilvelan, 2014)

Therefore, in this study nickel-composite coating will be deposited on AA7075 in order to improve its surface properties such as wear resistant, anti-friction resistant, and corrosion resistant. Nickel was chosen as a metal matrix because it has tensile strength, good toughness, and corrosion resistance. There are various techniques that can be used to prepare a composite coating, such as thermal spray, physical vapor deposition, chemical vapor deposition and electro-co-deposition (Ramesh and Seshadri, 2003). In this study, electro-co-deposition will be used as a method to electrodeposit nickel-composite coating on the substrate.

Fly ash (FA) particles will be used as a reinforcement in Ni-matrix. FA is a byproduct of thermal electric plants. Several studies shown FA can be used as additive to improve mechanical and chemical properties of metallic alloys especially magnesium and aluminum

(Panagopoulos *et al*., 2011). By codeposit FA in metal alloy the abrasion wear, wear resistance and will have low friction coefficient will be improved (Nguyen *et al*., 2013).

From comprehensive literature review, mostly composite coating of nickel matrix has been done by using an aqueous bath such as watt bath (Molina *et al*.,2004; Pradeep and Senthilvelan, 2014). The deposited of nickel using a non-aqueous solvent are rarely reported (Shrestha and Saji, 2004). Nowadays, the electrodeposition of metal by using non-aqueous solvent has been studied. Traditional aqueous solution sometime cannot be use because of the liberation of hydrogen molecule during electrolysis, narrow electrochemical windows, low thermal stability and evaporation (Simka *et al*., 2009). To solve this problem, electrolyte from non-aqueous have been used to avoid hydrogen embrittlement, to improve the wettability of the electrode and to realize a wide electrochemical window (Thiemig and Bund, 2009). Another benefit by using non -aqueous bath also the metal can be deposited at overpotentials without vigorous hydrogen evolution where this situation happen in aqueous bath (Neurohr *et al., 2015)*

1.2 Problem Statement

AA7075 can easily experience corrosion process, thus coating system is use to improve the corrosion resistant of the AA7075. Usually, cadmium and chromium was use as a coating for AA7075 in an aircraft industry. This type of coating material was replace with other coating material such as nickel phosphorus (Ni-P), Zinc (Zn) and polycrystalline nickel (Ni). This replacement happen due to cadmium and chromium are venturous and contain a cancer component that might cause cancer. Nowadays, green material are started be use by people due to it sustainable, environmental friendly and annual renewable sources. Therefore, fly ash has been use to be as an inert particle in the coating to improve the properties of the coating.

The selection of an electroplating bath depends primarily on the required characteristic of the nickel deposit. Usually, a bath is filling with an aqueous solvent. A Watts bath is a most popular nickel electroplating bath from an aqueous solvent. However, not all particles can

easily codeposited from an aqueous bath. The most hydrophilic particles like SiO_2 are barely codeposited with nickel when using an aqueous bath. However, SiO_2 is easy to be codeposited with a metal from a non-aqueous metal plating bath (Shrestha and Saji, 2004). The disadvantage of using aqueous bath is the discharge of H^+ ions and the evolution of hydrogen during electrodeposition process. It is because the discharge of hydrogen take place during plating which can affect the deposition process and crystallographic structure (Chaudhari and Singh, 2014). The coating also become uneven because of the much hydrogen generated on surface of the working electrode (Neurohr et al., 2015). Therefore, in this study non-aqueous solvent will use be to electrodeposit nickel-fly ash (Ni-FA) composite coating on aluminum alloy 7075 substrate and the effect of various current density on the hardness and corrosion properties of electrodeposited Ni-FA composites coatings on AA7075 substrate will be main focus in this research.

1.3 Objective

i. To study the effect of various current density on the hardness properties of electrodeposited Ni-FA composite coatings on AA7075 substrate from non-aqueous media.

ii. To investigate the influence of various current density on the corrosion properties of electrodeposited Ni-FA composite coating on AA7075 substrate from non-aqueous media.

iii. To examine the effect of annealing temperature on the properties of electrodeposited Ni-FA composite coating on AA7075 substrate from non-aqueous media.

1.4 Scope of Study

The scope of this study is to investigate the effect various current density to the electrodeposited of Ni-FA composite coating on AA7075 substrate from non-aqueous bath in term of the properties of the coating. The properties that study are corrosion resistance and hardness. For the electrodeposited method, nickel and AA7075 will be selected as anode and cathode respectively. The composition of electrolyte is prepared by using fixed amount of nickel salt and fly ash with non-aqueous solvent bath, which is ethylene glycol and the various amount current density is use during electrodeposition process. Firstly, AA7075 substrate will undergone surface pre-treatment such as grinding and polishing before go to plating process. After electrodeposition process, some of the sample will through the heat treatment process before characterization process is conducted on the sample. The characterization process will be done by using scanning electron microscope (SEM), X-ray diffraction (XRD), and X-ray fluorescence (XRF). The effect of various current density on the coating properties is investigated by hardness test and corrosion test. Finally, the result are going to be analyze.

CHAPTER 2
LITERATURE REVIEW

2.1 Composite Coating

2.1.1 Introduction

Composite is the combination of two or more substances of different materials with a distinct interface between them. The combining of material still maintain their identities but the combination will produce a different properties and characteristic from the combining material. One of the combining is form in continuous phase, known as a matrix and other combining is reinforcement in form of fibers or particular. Reinforcement will form a discontinuous phase. Reinforcement will be added to the matrix to improve the properties of the matrix. There are several type of composite coting such as metal matrix coating (MMCs), ceramic composite coating (CMCs), and polymer composite coating (PMCs). Usually the composites commercially are based on polymer matrices, but MMCs and CMCs from are good interest in high temperature application (Mallick, 1997). Reinforcement can be dividing into several types such as particulate, whiskers, and fibers. Figure 2.1 below show the types of reinforcement.

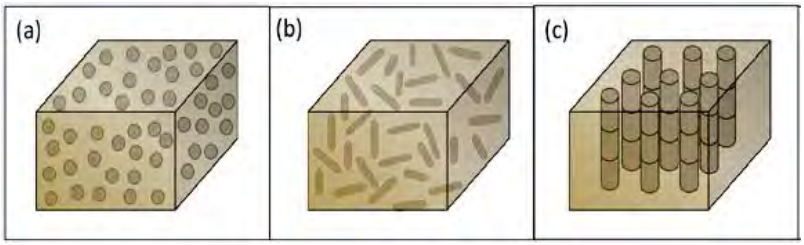

Figure 2.1: Type of reinforcement (a) particulate (b) whiskers (c) fibers (Owais & Ryu, 2016)