INFLUENCE OF BALL TO POWDER RATIO AND HEAT TREATMENT PROCESS ON THE PROPERTIES OF ELECTRODEPOSITED NICKEL-QUARRY DUST COMPOSITE COATING

Submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Hons.)

by

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Tajuk: **INFLUENCE OF BALL TO POWDER RATIO AND HEAT TREATMENT PROCESS ON THE PROPERTIES OF ELECTRODEPOSITED NICKEL-QUARRY DUST COMPOSITE COATING**

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Author’s Name: NUR SYAKIRAH BINTI PUTEH

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Hons.).

The members of the supervisory committee are as follow:

…….

(Dr. Intan Sharhida binti Othman)

ABSTRAK

Tujuan kajian ini adalah untuk menilai sifat-sifat mekanikal dan mengkaji pengaruh nisbah bola terhadap berat serbuk dalam proses kisar bola pada sifat-sifat elektrodeposit nikel-kuari komposit lapisan debu. Dalam kajian ini, keluli berkelajuan tinggi (HSS) akan digunakan sebagai substrat. Serbuk kuari akan disediakan dan melekat ke substrat keluli kelajuan tinggi (HSS) dengan menggunakan proses elektrodeposisi. Serbuk kuari digilap menggunakan pelbagai nisbah bola terhadap berat serbuk (BPR) dalam kisaran bola. Substrat HSS akan menjalani pra-rawatan mekanikal dan kimia sebelum proses elektrodeposisi. Nikel modifikasi komposisi Watt akan disediakan. Selanjutnya, elektrodeposited nikel-kuari pelapis komposit serbuk dijalankan selama satu jam dan selepas itu disertakan dengan rawatan haba untuk pengerasan salutan. Pengaruh pelbagai nisbah bola terhadap berat serbuk pada permukaan morfologi, komposisi unsur, kekasaran permukaan, struktur kristal, sifat haus dan kekerasan dikaji. Lapisan komposit akan dicirikan dengan menggunakan SEM, XRD dan penguji kekasaran. Kemudian, pengaruh pelbagai nisbah bola terhadap berat serbuk pada lapisan komposit akan dinilai dengan menggunakan ujian kekerasan dan ujian kehausan. Nisbah bola ke berat serbuk memberi kesan ke atas pengurangan saiz zarah serbuk kuari. Saiz serbuk kuari hampir sama iaitu kurang daripada 10 mikronmeter untuk BPR 8: 1,10: 1,12: 1, 14: 1 dan 16: 1 manakala nilai serbuk kuari yang asal ialah 210.063 micronmeter. Kekerasan lapisan komposit serbuk kuari elektrodeposit berkurang sebanyak 10 °C apabila menggunakan rawatan haba.

ABSTRACT

The aim of this study is to evaluate the mechanical properties and study the influence of ball to powder weight ratio in ball milling process on the properties of electrodeposited nickel-quarry dust composite coating. In this study, high speed steels (HSS) was used as a substrate. Quarry dust will be prepared and co-deposited onto high speed steel (HSS) substrate by using electrodeposition process. Quarry dust have been milled for various ball to powder weight ratio (BPR) in planetary ball milling. The HSS substrate was undergone mechanical and chemical pre-treatment prior to the electrodeposition process. The nickel modified Watt's bath will be prepared. Next, electrodeposited nickel-quarry dusts composite coatings were performed for one hour and subsequent by heat treatment for harden the coatings. The influence of various ball to powder weight ratio on the surface morphology, elemental composition, surface roughness, crystal structure, wear and hardness properties will be studied. The composite coatings was characterized using scanning electron microscope (SEM), X-Ray Diffraction (XRD) and surface Roughness Tester. Then, the influence of various ball to powder weight ratio on the composite coatings was evaluated using hardness test and wear test. Ball to powder weight ratio gives effect on the reduction of particle size of quarry dust. The size of quarry dust almost same which was below 10 micronmeter for BPR 8:1, 10:1, 12:1, 14:1 and 16:1 while value particle size for as-received quarry dust was 210.063 micronmeter. The hardness of the electrodeposited nickel-quarry dust composite coating decreases about 10 °C when applying heat treatment.

DEDICATION

Only

my beloved father, Puteh bin Ngah

my appreciated mother, Norridah binti Johari

my adored sister and brother, Nur Safikah binti Puteh and Muhammad Amirul Ammar binti Puteh

for giving me moral support, money, cooperation, encouragement, and also understandings Thank You So Much & Love You All Forever

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TABLE OF CONTENT

CHAPTER 2 : LITERATURE REVIEW

CHAPTER 3 : METHODOLOGY

CHAPTER 4 : RESULT AND DISCUSSION

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ASTM	-	American Society for Testing and
Materials BPR	-	Ball to Powder Weight Ratio
EDM	-	Electrical Discharge Machining
HSS	-	High Speed Steel
QD	-	Quarry dust
SDS	-	Sodium Dodecyle Sulfate
SEM	-	Scanning Electron Microscopy
SLS	-	Sodium Lauryl Sulphate
UTeM	-	Universiti Teknikal Malaysia Melaka
XRD	-	X-Ray Diffraction

LIST OF SYMBOLS

°C	-	Degree Celcius
Al_2O_3	-	Alumina
C	-	Carbon
cm	-	Centimetre
Cr	-	Chromium
Fe	-	Iron
g/L	-	Gram per litre
H_3BO_3	-	Boric Acid
Mn	-	Manganese
Mo	-	Molybdenum
N	-	Newton
Ni	-	Nickel
Ni/SiC	-	Nickel/ silicon carbide
$Ni_2SO_4.6H_2O$	-	Nickel sulfate
Ni-Al	-	Nickel Aluminum
$NiCl_2.6H_2O$	-	Nickel Chloride
Ni-P	-	Nickel Phosphorus
rpm	-	Revolution per minutes
Si	-	Silicon
SiO_2	-	Silica
V	-	Vanadium
W	-	Tungsten
wt.%	-	Weight percentage
ZrO_2	-	Zirconium Dioxide

CHAPTER 1

INTRODUCTION

This chapter explained about background of study, problem statement, objectives, scopes of study, significant of study, organization of the report and an overall summarization for this chapter.

1.1 Background of Study

In manufacturing industry, it is important to get good surface properties of the product. There are interested to get a high quality product by using many techniques of coating to achieve better surface properties such as high hardness and wear resistance. Electrodeposited composite coating is a simple technique of coating that enhanced properties such as the surface roughness, wear resistance, hardness and uniformity of distribution relative to pure metal, so that it can be protected the metal substrates to more effectively during the operation (Das et al., 2017). Hardness of a material is one of the most crucial mechanical properties which relates to the mechanical strength and wear resistance in order to improve the life span of the product (He et al., 2012). Based on Praveen & Venkatesha (2009), the generating of metal nanoparticles composite coatings are centered by many researchers and evaluating the material properties.

Nickel is a vital necessary metal material that widely used in modern technology industry and an extreme effect on mechanical properties of electrodeposited coating can be achieved with the main parameter (Yang-tao et al., (2017). The usage of pure nickel in the electrodeposited

coating results in high hardness but low wear resistance. Quarry dust is a flaky and sharp edge of waste material that produced from production of crushed granite stones in quarrying activities (Bashar et al., (2016). The reuse of quarry dust will contribute sustainability. The particle size of quarry dust must be refined to become as smaller as possible in order to use in the electrodeposited coatings. This is because the small particle of quarry dust will give great result in surface properties of the substrate.

Hence, ball milling process is used to refine the particle size of the quarry dust for electrodeposited coatings. Small size of the quarry dust is necessary in electrodeposited coating as it influence the surface properties of the substrate. Small particles of quarry dust contribute uniform distribution in the coating. Ball milling can be defined as a powerful and smooth processing technique where specified quantity of powder is loaded into milling machine and the interaction between ball and the wall occurred with the presence of friction. There are some parameters that are affecting the performance of ball milling process to achieve required particle size, including ball to powder weight ratio (BPR), rotational speed, ball diameter and process time.

The ball to powder weight ratio is one of the processing parameter that is usually used in mechanical (ball) milling and mechanical alloying. So, influence of ball to powder weight ratio in ball milling process on the properties of electrodeposited nickel-quarry dust composite coating is studied. In order to obtain small particle size of quarry dust, ball to powder weight ratio parameter plays an important role in the ball milling process. Hence, the best option of the ball to powder weight ratio will produces a small particle of the quarry dust. Heat treatment is applied with increasing the temperature to harden the surface properties by altering the microstructure of the substrates. Moreover, microstructures of the metals such as grain size, residue stress and crack and improvement of hardness of the coatings can be changed by applying the heat treatment after coating process.

Surface properties of the electrodeposited composite coating can be tested using Vickers microhardness for testing the hardness while micro tribo pod tester machine for

testing the wear resistance. The composite coatings will be characterized using scanning electron microscope (SEM), X-RayDiffraction (XRD), Roughness Tester and X-Ray Fluorescence (XRF). The deposits of the microhardness of the substrate can be determined by microhardness Vickers (Praveen & Venkatesha, 2009).

1.2 Problem Statement

High speed steel (HSS) is the type of material used for cutting tool because its ability to perform a material removal at a high speed. It is an alloying element that creates properties against hardness and wear resistance. The problem that usually occurs when using the HSS as the cutting tool is the tool life. The HSS will worn out during the machining process. This is because of the friction present along the workpiece. It makes the tool life span not long lasting. The cutting tool life span can be prolonged by coating the tool.

Quarry dust is a by-product from the granite crushing process in quarrying activities (Raman et al., 2011). Quarry dust can be used as reinforcement in a composite coating in order to improve the hardness and wear resistance of a composite coating. Quarry dust contains high composition of SiO_2 and considerable amount of Al_2O_3 which suitable for composite coating to improve the surface properties of the substrate. It is in irregular shape and large in particle size. In co-deposition process, the size of reinforcement plays a main role in determining the properties of the composite coatings. Due to the large size reinforcement, the dispersion of the particles in the electrolyte will not uniform. The large particles of reinforcement will tend to be at the bottom of the electrolyte tank because of the gravity. Hence, the amount of particles which will be co-deposited in metal matrix onto the substrate will be less than the amount added to the electrolyte.

Therefore, a ball milling process is required in order to refine the reinforcement size and to maximize the amount of reinforcement co-deposited in the coatings. The ball to powder weight ratio is a main parameter in this project to refine the quarry dust and heat treatment should be applied after coating process to increase the hardness and the wear resistance of the

composite coatings.

1.3 Objectives

The objectives that must achieve within this project are:

(a) To study the effect of various ball to powder weight ratio and heat treatment on the surface morphology of electrodeposited nickel quarry dust composite coating.

(b) To investigate the influence of various ball to powder weight ratio and heat treatment on hardness of electrodeposited nickel quarry dust composite coating.

(c) To examine the influence of various ball to powder weight ratio and heat treatment on wear resistance properties of electrodeposited nickel quarry dust composite coating.

1.4 Scope

The scope of this project is to investigate the improvement of the surface properties of the electrodeposited nickel quarry dust composite coating. This project is carried out to study the effect of various ball to powder weight ratio and heat treatment on the surface morphology of electrodeposited nickel quarry dust composite coating. The main parameter that influenced the surface properties of coating is ball to powder weight ratio in ball milling. There are various of ball to powder weight ratio that is used in ball milling. The purpose of using parameter ball to powder weight ratio is to refine the particles size of the quarry dust into smaller particles for coating purposes.

The next scope for this project is to investigate the various ball to powder weight ratio and heat treatment on the hardness of the electrodeposited nickel quarry dust composite coating. This project will cover on the parameter ball to powder weight ratio that affected on

the hardness of the surface electrodeposited composite coating subsequent by heat treatment. The other scope is to examine the various ball to powder weight ratio and heat treatment on the wear resistance of composite coating. The heat treatment is applied in this project coating to alter the microstructure of the materials in order to harden the composite coating.

After applying the ball to powder weight ratio in ball milling for process coating and subsequent by heat treatment, the surface properties of the electrodeposited composite coating can be improved. This project will show the result of the surface properties of the electrodeposited composite coating by using parameter ball to powder weight ratio and heat treatment after coating. This project was conducted at the laboratory in Universiti Teknikal Malaysia Melaka (UTeM) by using planetary ball milling for study the ball to powder weight ratio. The coating process and heat treatment after coating also conducted at the laboratory in UTeM.

1.5 Significant of Study

The significance of this project is to enhance the surface properties of the product by coating. The coating process used parameter ball to powder weight ratio in ball milling to refine the particle size of quarry dust. By using small size of quarry dust, the quarry dust uniformly distribute during coating process. Hence, it will increase the value and productivity of the product. This project will be beneficial to the industry especially industry automotive. It is because the coatings have high quality of product in term of high hardness and wear resistance. This coating also can improve the performance and life span. This project of coating also will give benefit to the industry where the company will have less of maintenance for their product. Thus, it will make the company especially industry automotive have low maintenance cost.

Note that, parameter ball to powder weight ratio in ball milling will be used to refine the particle size into nanopowders (Liu et al., 2010). This will produce good surface of coating. By using coating, the product will provide excellent corrosion protection as well

waterproofing. They also protect against fire, heat, stress and UV light. Coating produce longer- lasting product as it have been shielded with a strong coat layer. It will give more profit to the company as the company no need to buy or replace something new of the product for short time**.**

1.6 Organization of the Report

In overall, these project are majorly consists of five sections. The five sections are introduction, literature review, methodology, result and discussion and in addition conclusion and recommendation.

Chapter 1: Introduction

This section provides a synopsis of study about this project, problem statement of this project, objective and lastly scope. It is involve the hugeness or important of this exploration to the industry.

Chapter 2: Literature Review

Literature review is a section that emphasized on writing audit on past related research on the topic. This section involves the crucial procedure to refine the particle size of the quarry dust into smaller particles that is used in electrodeposited composite coating and subsequent by heat treatment. Concerning of this project, electrodeposited composite coating is used to provide better productivity and performance compared to product without doing coating.

Chapter 3: Methodology

In this chapter, method involved is covered in order to explain the preparation of the experiment, testing method and studies of each sample. The electrodeposited composite coating and refinement the quarry dust using ball milling are present.

Chapter 4: Result and Discussion

All results and finding from the project are explained and analyzed in chapter four. The surface properties of electrodeposited composite coating that influence by ball to powder weight ratio (BPR) in ball milling and subsequent by heat treatment will be discussed in this chapter.

Chapter 5: Conclusion and Recommendation

This chapter concludes the overall aspect of the project. The though and recommended keeping in mind the end goal to enhanced the examination later on.

1.7 Summary

It can be concluded that further and detail information about background of study, problem statement, scope of study, significant of study and also structure of report are included in Chapter 1.