UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MECHANICAL PROPERTIES OF W/CU-ZN METAL COMPOSITE VIA MECHANICAL ALLOYING

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

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ABSTRACT

The purpose of this research is investigate the mechanical alloying process of 40%W-30% Zn-30% Cu from the elemental powders of W, Zn and C by a high energy ball mill in argon atmosphere was investigated. The mechanical alloying process parameters such as milling speed and milling time, were varied in order to investigate their influence on the micro structural evolution of mechanically alloyed powders. The mechanical alloying process proceeded following two sample A and B Including sample A is 20% Cu,40% Zn and 40%W,sample B,30% Cu, 30% Zn and 40% W, the sample would be sintered at temperature 850 degree of celcius by heating is 10 degree celcius per minute.. The microstructure of the alloy sample would be identifying by using SEM and immersion method has been used for corrosion test to test weight loss. The mechanical test that involve in this research is hardness test by using micro Vickers and density by using Archimedes method. Hardness test showed that sample A is higher than sample B. the value is 69.3hv, it because increasing the milling time is one of the factor it could be highest. Rotational speeds of ball milling reduce the size of particle and make the composition of that alloy become more refine and little porosity. OM and SEM were used to analyze the microstructure. For the density result, the highest peak of density for sample B is at 50rpm and 24hour, 7.561 g/cm^3 and the lowest at 100rpm 48 hour, 6.31 g/cm^3 before sintering, the decrease of the green density with the milling time can be due to many factors. Sample A at parameter 50rpm and 48 hour is a high corrosion resistance by affect of the smallest grain size and microstructure.

ABSTRAK

Tujuan dari penyelidikan ini adalah mengetahui proses mekanikal campuran 40% W-30% Zn-30% Cu dari serbuk unsur W, Zn dan Cu dengan tenaga kualiti pengilingan bola di atmosfera argon diselidik .Parameter yang terlibat di dalam mekanikal campuran seperti penggilingan kelajuan, penggilingan masa, bola-ke-serbuk nisbah dan nisbah bola mengisi divariasikan untuk mengetahui pengaruh mereka pada evolusi struktur mikro gabungan serbuk mekanikal. Di dalam proses ini, dua sampel A and B. Termasuk sampel adalah Cu 20%, 40% dan 40% Zn L, sampel B, 30% Cu, Zn 30% dan 40% P. sampel akan disinter pada suhu 600 darjah celcius dengan kadar pemanasan sebanyak 10 darjah celcius per minit. Proses sintering adalah tiga jam. Struktur mikro sampel campuran akan mengenal pasti dengan menggunakan SEM dan kaedah perendaman telah digunakan untuk ujian kakisan untuk menguji penurunan berat kandungan sampel. Ujian mekanikal yang terlibat dalam penelitian ini adalah uji kekerasan dengan menggunakan micro Vickers. Ujian kekerasan menunjukkan sample a lebih tinggi daripada sampel b iaitu 69.3hv.ini kerana masa penggilingan mempengaruhi saiz partikel aloi tersebut. OM dan SEM digunakan menganalisa mikro struktur bahan tersebut. Untuk hasil ketumpatan, puncak tetinngi sampel B ialah pada 50rpm dan 24hour,7,561 g / cm ^ 3 dan terendah di 100rpm 48 jam, 6,31 g / cm ^ 3 sebelum disinter, penurunan kepadatan hijau dengan waktu penggilingan boleh disebabkan oleh banyak faktor. Sampel A pada50rpm parameter dan 48 jam adalah keta hanan terhadap kakisanyang tinggi oleh pengaruh saiz butir terkecil.

DEDICATION

Special dedication to my mum and family members that always love me,
my supervisor, my beloved friends, my fellow colleague,
and all faculty members

For all your love, care, support, and believe in me

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LIST ABBREVIATIONS

Cu -Copper

W -Tungsten

Zn Zinc

`Pb -Plumbum

NaCl –Sodium chloride

SEM – scanning electron microscopy

MMC –metal matrix composite

P/M – powder metallurgy

mm – millimeter

F – farad

LPC – low pressure carburizing

HPGQ –high pressure gas

TIG – tungsten inert gas

rpm – revolution per minute

Mpa – megapascal

T - Temperature

LIST OF SYMBOLS

% -Percentage

C –Celcius

CHAPTER 1

INTRODUCTION

In this chapter, it will explain about how to do the research, objective and scope of the project. The title of the research is investigating the microstructure of the Cu, Zn and W by using mechanical alloying method.

1.1 Background study

Nowadays alloy has been using at any place by any function. Alloy has been chosen because their special characteristic. An alloy is a partial or complete solid solution of one or more elements in a metallic matrix. Complete solid solution alloys give single solid phase microstructure, while partial solutions give two or more phases that may be homogeneous in distribution depending on thermal (heat treatment) history. Alloys usually have different properties from those of the component elements. There are many types alloys for example metal or non metal. Alloying one metal with other metal(s) or non metal(s) often enhances its properties. For example, steel is stronger than iron, its primary element.

The physical properties, such as density, reactivity, Young's modulus, and electrical and thermal conductivity, of an alloy may not differ greatly from those of its elements, but engineering properties, such as tensile strength and shear strength may be substantially different from those of the constituent materials (Callister ,2007).

This is sometimes due to the sizes of the atoms in the alloy, since larger atoms exert a compressive force on neighboring atoms, and smaller atoms exert a tensile force on their neighbors, helping the alloy resist deformation. Sometimes alloys may exhibit marked differences in behavior even when small amounts of one element occur. For example, impurities in semi-conducting ferromagnetic alloys lead to different properties.

The mechanical properties of alloy depend on their making process. We should consider is their content before us mixture to each other. For example, to make an alloy, we should add 40% W, 30% Zn and 30% of Cu. Different of material content will affect their properties. Besides, the mechanical alloying process parameters such as milling speed, milling time, ball-to-powder ratio and ball filling ratio will also influenced on the microstructure evolution as well as their mechanical properties (J. Ryu, Soon H. Hong and Woon H. Baek ,1997).

In this study, the effects of mechanical alloying process parameters such as, milling speed, milling time, ball-to-powder ratio and ball filling ratio, on the microstructure of mechanically alloyed tungsten heavy alloy powders were investigated. The experimental results were compared to the calculated results based on theoretical models to clarify the relationship between the mechanical alloying process parameters and microstructure evolution. After sintering at temperature ranged 600-800°C, the average tungsten particle size and sintered density of sintered tungsten heavy alloy from mechanically alloyed powders were investigated compared to those of tungsten heavy alloy from conventionally blended powders. The toughness of alloy will be test in hardness test.

1.2 Problem statement

Nowadays, there are many types of alloy such as magnesium alloy, aluminum alloy and others. . There are many applications that we can use this alloy, for example fishing sinker. Previously, they used lead (Pb) as their material which is more dangerous to the environment. So, the solution for fishing sinker maker is, we change previous material to Cu-Zn-W which is more reliable, environmental friendly, nontoxic, and give better properties. However, recently, tungsten alloy sinker is becoming more and more popular among angles because it has the features of high density, small volume, and environmental friendly, and has been taking place of the lead sinker. Jigs are intended to create a jerky, vertical motion, as opposed to spinner baits which move through the water horizontally. The jig is very versatile and can be used in both salt water as well as fresh water.

1.3 Objective

The main objectives of this research is to study the alloy microstructure by setting a certain parameters such as ball-to-powder ratio and ball filling ratio , time and speed of ball mill. Besides, the next objective is to investigate the mechanical properties of this alloy.

1.4 Scope of the project

(a) Study on mechanical properties of W/Cu-Zn alloy with ratio:

(i) 30%Cu, 30% Zn and 40%W

(ii) 20%Cu, 40% Zn and 40%W

(b) Study the parameters affecting mechanical properties of alloy

- milling speed
- milling time

(c) Laboratory material analysis test

(i) Electrochemical test by using 3.5 % NaCl

(ii) Harness test by using Rockwell or Vickers test

(iii) Specimen analysis by using Scanning electron microscopy (SEM)

CHAPTER 2

LITERATURE REVIEW

This chapter will discuss on the related study based on the previous research conducted by other researchers on the metal matrix composite by using mechanical alloying for fishing application. The literature review mainly focused on the theory of metal matrix composite and the effects of some parameters in mechanical alloying. Through this chapter also, the study on various types of mechanical properties testing analysis that related to the study were studied and discussed.

2.1 Metal matrix composite

Metal matrix composite materials have found in many applications in many areas of daily life some time. Often it is not realized that the application makes use of composite materials. Here, the Dalmatian sword previous research with its meander structure, which results from welding two types of steel by repeated forging, can be mentioned. Materials like cast iron with graphite or steel with high carbide content, as well as tungsten carbides, consisting of carbides and metallic binders, also belong to this group of composite materials. For many researchers the term metal matrix composites is often equated with the term light metal matrix composites (MMCs).

Substantial progress in the development of light metal matrix composites has been achieved in recent decades, so that they could be introduced into the most important applications. In traffic engineering, especially in the automotive industry, MMCs have been used commercially in fiber reinforced pistons and aluminum crank cases with strengthened cylinder surfaces as well as particle-strengthened brake disks (Callister, 2007).

These innovative materials open up unlimited possibilities for modern material science and development; the characteristics of MMCs can be designed into the material, custom-made, dependent on the application. From this potential, metal matrix composites fulfill all the desired conceptions of the designer. This material group becomes interesting for use as constructional and functional materials, if the property profile of conventional materials either does not reach the increased standards of specific demands, or is the solution of the problem. However, the technology of MMCs is in competition with other modern material technologies, for example powder metallurgy. The advantages of the composite materials are only realized when there is a reasonable cost – performance relationship in the component production. The use of a composite material is obligatory if a special property profile can only be achieved by application of these materials.

The reinforcement of metals can have many different objectives. The reinforcement of light metals opens up the possibility of application of these materials in areas where weight reduction has first priority. Callister , (2007, pp.604), claims that the super alloys, as well as alloys of aluminum, magnesium, titanium, and copper, are employed as matrix materials. The reinforcement may be in the form of particulates, both continuous and discontinuous fibers, and whiskers; concentrations normally range between 10 and 60%.

2.2 Mechanical alloying

From previous research, Li Lu and Man On Lai, (1998) states that, mechanical alloying is a ball milling process where a powder mixture placed in the ball mill is subjected to high energy collision from the balls. The process is usually carried out in an inert atmosphere. It is an alternative technique for producing metallic and ceramic powder particles in the solid state. The most important events involved in mechanical alloying are the repeated welding and fracturing of the powder mixture. The alloying process can only be continued if the rate fracturing and the average particle size of the powders remain relatively coarse. Alloy with different combination of elements have been successfully synthesized due to the uniqueness of the process being able to produce new materials from the bottom of the phase diagrams. Since mechanical alloying is a solid state process, it provides means to overcome the drawback of formation of new alloys using a starting mixture of low and high melting temperature elements.

2.2.1 Powder production

The raw material for p/m components is the powder. These powders are engineered materials in the sense they are manufactured to precise specifications to facilitate subsequent processing. The powders used in P/M can be pure elements, elemental blends or pre alloyed powders. The choice of starting material is influenced by the product type and to a lesser extent by the fabrication process to be used. Several production methods are available for making powders. Most common method produces powders of both ferrous and nonferrous metal; specialty powders like stainless steel, super alloy (nickel base) as well as titanium alloy powders are also made by technique. Reduction of compounds is another widely used technique used for the production of iron, copper as well as tungsten.

2.2.2 Compaction

Figures 2.1 Manually Hydraulic Press From Fkp Lab

By using 10 ton as pressure and used 10mm diameter of pallet dies, each of the powder samples will be compact by using hydraulic presses according to figure 2.1.Compaction of powder mixture is generally carried out using dies machined to close tolerances. Dies are made typically from die steels or cemented carbides. Equipment used for compaction includes mechanically or hydraulic presses, the latter being more common due to their safe operation and flexibility. Die design is important and must ensure easy ejection of compact. The powder type and its characteristic influence the compaction pressure. The basic purpose of compaction is to produce a green compact with sufficient strength to withstand further handling operations. The presses part, usually called the 'green compact' is then taken for sintering. Consolidation of powers may also be carried out at high temperature. Hot extrusion, hot pressing and hot isostatic pressing are example of this category. These methods are used for critical metallic and ceramic requiring near theoretical density (Li Lu and Man On Lai, 1998).

2.2.3 Sintering

Sintering is a method for making objects from powder, by heating the material in a sintering furnace below its melting point (solid state sintering) until its particles adhere to each other. Sintering is traditionally used for manufacturing ceramic objects, and has also found uses in such fields as powder metallurgy. Sintering is effective when the process reduces the porosity and enhances properties such as strength, translucency and thermal conductivity; yet, in other cases, it may be useful to increase its strength but keep its gas absorbency constant. During the firing process and as it continues; grain size becomes smaller and more spherical because the particle's surface tends to flow into the pores within it based on the difference between vapor-pressure and cross-sectional area of the pores' neck (Callister, 2007).

For properties such as strength and conductivity, the bond area in relation to the particle size is the determining factor. The variables that can be controlled for any given material are the temperature and the initial grain size, because the vapor pressure depends upon temperature.

The source of power for solid-state processes is the change in free or chemical potential energy between the neck and the surface of the particle. This energy creates a transfer of material though the fastest means possible; if transfer were to take place from the particle volume or the grain boundary between particles then there will be particle reduction and pore destruction. The pore elimination occurs faster for a trial with many pores of uniform size and higher porosity where the boundary diffusion distance is smaller. Oxides, for instance, are fine-grained particles that even during the beginning process of heat treatment, both the grain size and the pore size increase. For the latter portions of the process boundary and lattice diffusion from the boundary become important.

To control the sintering process, temperature is very important to control, since grain-boundary diffusion and volume diffusion rely heavily upon temperature, the size and distribution of particles of the material, the materials composition, and often the sintering environment to be controlled. To control the sintering process, temperature is very important to control, since grain-boundary diffusion and volume diffusion rely heavily upon temperature, the size and distribution of particles of the material, the materials composition, and often the sintering environment to be controlled.

2.2.3.1 Sintering mechanisms

Sintering occurs by diffusion of atoms through the microstructure. This diffusion is caused by a gradient of chemical potential – atoms move from an area of higher chemical potential to an area of lower chemical potential. The different paths the atoms take to get from one spot to another are the sintering mechanisms. The six common mechanisms are:

a) Surface diffusion - Diffusion of atoms along the surface of a particle

b) Vapor transport – Evaporation of atoms which condense on a different surface

c) Lattice diffusion from surface – atoms from surface diffuse through lattice

d) Lattice diffusion from grain boundary – atom from grain boundary diffuses through lattice

e) Grain boundary diffusion – atoms diffuse along ground boundary

f) Plastic deformation – dislocation motion causes flow of matter