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STUDY OF MECHANICAL PROPERTIES OF SINTERED CUZN30 (BRASS) - MWCNT COMPOSITE FABRICATED BY POWDER METALLURGY.

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ABSTRACT

The number of engineering application in industry demands need light weight, good mechanical properties of material such as aerospace, automotive industry. Day by day selection of material with good mechanical property is the pin point for material selection, hence because it's high stiffness CNT are considered for widely used reinforcement of material in metal matrix Composite. These work summaries the research work carried out in the field of carbon nanotube (CNT) metal reinforcement for composite material. However, CNT-reinforced CuZn30 (Brass) has received the least attention, so that this work also explore more data regarding CNT reinforced CuZn30 (Brass). The main aim of this project is to fabricate and study the mechanical as well as Tribological properties of CuZn30-MWCNT composite. Multiwall carbon nanotubes (MWCNTs) reinforced CuZn30 Nano composites are fabricated by mechanical alloying and powder metallurgy technique. The reinforcement material MWCNTs are blended in three weight fractions (0.33%, 0.66%, and 0.99%) with the matrix material CuZn30 (Cu-70%, Zn-30%) and blended through mechanical alloying using a high energy planetary ball mill. Specimens of CuZn30 and CuZn30-MWCNT composites are fabricated through powder metallurgy technique. After fabrication of CuZn30-MWCNT it is sintered to arranged CNT in unidirectional. The microstructure, density, hardness, porosity, and wear properties of CuZn30 and CuZn30-MWCNT Nano composites are characterized and compared with pure CuZn30 composite for the effect of addition of MWCNT.

KEYWORDS:CuZn30 (Brass), MWCNT, PM, Mechanical

INTRODUCTION

CuZn30 (Brass) have been widely used in tribological engineering parts, sliding bearings and also in electrical and thermal devices. These composites have been characterized for their high mechanical strength, friction, electrical resistivity and thermal conductivity. Diverse efforts have been CuZn30 (Brass) focusing on improving their mechanical, tribological properties useful for specific applications. To overcome this problem, many studies have been carried out on incorporation of various additives in the composites in order to increase the interface strength and improve the mechanical, electrical and thermal properties of the composites for various applications. Various methods have been adopted to prepare Cu composites of excellent mechanical and physical properties, such as powder metallurgy, impregnation, and hot isotactic pressing and chemical reduction method. Out of these methods, powder metallurgical route has shown many advantages over these methods for the possibility of obtaining good quality composites with low cost. Nowadays, carbon nanotubes (CNT) have received significant attentionas a reinforcement material in the polymer, metal and ceramic matrix materials for the development of high quality composites, which is due to their excellent mechanical and tribological properties. Therefore, in present research work, we have studied influence of multiwall carbon nanotubes (MWCNT) reinforced in CuZn30 (Brass) and developed CuZn30 (Brass)/ CNT composites through powder metallurgy technique without using any extra binder to produce high performance composites. CuZn30 (Brass)/ CNT composites have been investigated for structural, mechanical, tribological properties.

Composite materials are becoming necessary for modern technologies in order to improve both mechanical and physical properties of materials. Composite are a physical mixture in macroscopic scale which is made of two or more materials. The ingredients preserve their physical and chemical properties; however the mixture provides even better properties than its constituents. Metal-matrix composites (MMC) have widely developed in recent years; e.g.

aluminum-matrix composites which caused huge efficiency and diversity in the industry. Since 1991 that it was discovered by Ijima, CNT is widely used and investigated in different materials. Carbon nanotube is accounted as reinforcement due to its great physical and mechanical properties. Due to high strength, elastic modulus, flexibility, conductivity and other properties, CNT is widely used and studied as reinforcement in composite materials. Copper-matrix composites also show low thermal expansion coefficient, high stiffness, electrical and thermal conductivity and strength and proper wear resistance. Copper- or graphite-matrix composite combine diverse properties; they are efficient at high temperatures and also show high electrical and thermal conductivity. Hence, copper and carbon nanotube composition may produce unique properties such as high and improved mechanical strength and thermal and electrical conductivity, low thermal expansion coefficient and enhanced hardness and wear resistance. Carbon nanotubes as reinforcement would cause increase of strength and physical and mechanical properties improvement in metal- or ceramic-matrix composites. It may be regarded to the remarkable mechanical and physical properties of carbon nanotubes. Copper and CNT Nano composites (Cu-CNT) have been manufactured by various procedures such as mechanical milling method, chemical and molecular method (wet chemistry), electrolytic method, molecular- mechanical milling method and some other procedures. The most significant issue in processing these Nano composites is distribution of carbon nanotubes in copper matrix. The carbon nanotubes distribution is important so if it is problematic and nanotubes remained in cluster forms or agglomerated, composite properties would deteriorate. Powder metallurgy is used to produce metal-matrix composites reinforced with discontinuous fibers, particles and whiskers. In mechanical milling method, presence of initial particles with grain size of 3-45 microns in the mixture of copper powder and carbon nanotubes leads to improvement of mechanical properties for addition of CNT up to 0.5-1 wt. %. The measured sintering temperature for copper-CNT composition in this method is reported between 850 to 950°C. In this research, powder metallurgy was used to produce copper-matrix and CNT compositions. Pure copper powder containing diverse CNT weight percentages (0-3) was ground by planetary mills. Pure copper has a high conductivity but also is soft and limited for some applications; Properties of carbon nanotubes were incentive to use them in the copper matrix composites as reinforced. Goal of this research was to study the effect of CNT on mechanical properties of copper-matrix composites [1].

MATERIALS AND METHODS

Composite material specification

CuZn30 (Brass)

CuZn30 (Brass) is Copper based alloy in that Copper is base metal matrix composite.

Specifications of MWCNT

The specification of MWCNT shown in table 3.2. The reinforcement material MWCNT with three weight fractions of 0.33%, 0.66%, and 0.99% is add to the matrix of CuZn30 (Brass).

Powder metallurgy

Powder metallurgy is the process of blending fine powdered materials, pressing them into a desired shape or form (compacting), and then heating the compressed material in a controlled atmosphere to bond the material (sintering). The powder metallurgy process generally consists of four basic steps: powder manufacture, powder blending, Compacting, and sintering. Compacting is generally performed at room temperature, and the elevated-temperature process of sintering is usually conducted at atmospheric pressure.

Uniaxial compacting

Powder compaction is the process of compacting metal powder in a die through the application of high pressures. Typically the tools are held in the vertical orientation with the punch tool forming the bottom of the cavity. The powder is then compacted into a shape and then ejected from the die cavity. In a number of these applications the parts may require very little additional work for their intended use; making for very cost efficient manufacturing.

Various homogenized powder mixtures of CuZn30 (Brass) and MWCNTs are then compacted at a pressure of 728 M Pa to form billets of 23 mm diameter and 40 mm height. Each billet is formed 150 gram of mixtures powder

fig 1 Compacted sample of CuZn30 (Brass)-MWCNT

Sintering

Sintering is the process of forming a solid mass of material by heat without melting it to the point of liquefaction. Form of a powder and placing it into a mould or die. Once compacted into the mould the material is placed under a high heat for a long period of time. Under heat, bonding takes place between the Sintering can be considered to proceed in three stages. During the first, neck growth proceeds rapidly but powder particles remain discrete. During the second, most densification occurs, the structure recrystallizes and particles diffuse into each other. During the third, isolated pores tend to become spheroidal and densification continues at a much lower rate. The words Solid State in Solid State Sintering simply refer to the state the material is in when it bonds, solid meaning the material is not turned molten to bond together as alloys are formed.

In this project work the compacted billets are then sintered in a tube furnace at 900°C without argon gas as protective atmosphere for 2 hours. The sintered sample is shown in fig 2.

fig 2 Sintered sample of CuZn30 (Brass)-MWCNT

Density and Porosity Measurement

The Archimedes' principle is used to measure the density of CuZn30 (Brass) and CuZn30 (Brass) Nano composites. For each of them, three randomly selected extruded rod samples are tested and the average density is calculated.

Experimental density (ρ) measurements are calculated in accordance with Archimedes' principle on specimens of pure CuZn30, and CuZn30-MWCNT, composites fabricated by using powder metallurgy route. The experimental setup is as shown in fig 3.10& fig 3.11 water is used as the immersion fluid. The specimen is first weighed in air, and then immersed and weighed again in a liquid with a known density, and the density of the specimen is calculated. We use water (1 g/cm^3) as auxiliary liquid.

The experimental density of the specimen is calculated from equation

$\rho_e = \quad W_a / ((W_a - W_x)/\rho_x)$

Porosity Measurement

Porosity or void fraction is a measure of the void (i.e., "empty") spaces in a material, and is a fraction of the volume of voids over the total volume, between 0 and 1, or as a percentage between 0 and 100%.Porosity of the specimens are calculated from the theoretical and experimental densities, using the following equation,

Porosity = $(\rho_{th} - \rho_e / \rho_{th} - \rho_a) * 100$

RESULTS AND DISCUSSION

Density

It is observed that the density of the Nano composites decreases with increasing weight percentages of MWCNTs. According to observation distribution of dislocations within the matrix of the composites would not be uniform and there will be higher density near the reinforcing particles. The reason for the decrease in the density is due to the addition of light weight and high volume MWCNTs compared to the matrix material. This is calculated by theoretically.

Table .1 Theoretical density of CuZn30 (Brass) -MWCNT composite

Composite	**Density (g/cm^3)**
CuZn30 (Brass)	7.6395
CuZn30 (Brass)-0.33%MWCNT	7.3156
CuZn30 (Brass)-0.66%MWCNT	7.2795
CuZn30 (Brass)-0.99%MWCNT	7.0718

The experimental green density can be find out by with Archimedes' principle. The experimental density values are given in table.2

Table -2 Experimental Green density of CuZn30 (Brass) -MWCNT composite

Composite	**Wt. in air (gm.)**	**Wt. in liquid(gm.)**	**Density (g/cm^3)**
CuZn30 (Brass)	149.9	130.2	7.6010
CuZn30 (Brass)-0.33%MWCNT	149.9	129.9	7.5196
CuZn30 (Brass)-0.66%MWCNT	149.9	130.0	7.5246
CuZn30(Brass)-0.99%MWCNT	149.8	129.6	7.4079

The experimental Sintered density can be find out by with Archimedes' principle. The experimental density values are given in table 3

Table .3 Experimental Sintered density of CuZn30 (Brass) -MWCNT composite

Composite	**Wt. in air(gm.)**	**Wt. in liquid(gm.)**	**Density (g/cm^3)**
CuZn30 (Brass)	150.0	130.3	7.6061
CuZn30 (Brass)-0.33%MWCNT	149.9	129.8	7.4498
CuZn30 (Brass)-0.66%MWCNT	150.1	129.4	7.2435
CuZn30 (Brass)-0.99%MWCNT	150.0	128.9	7.0442

Porosity

Porosity can be calculated from theoretical density and experimental density.

Table -4 Porosity of samples

Composite	**Porosity %**
CuZn30 (Brass)	0.43
CuZn30 (Brass)-0.33%MWCNT	0.46
CuZn30 (Brass)-0.66%MWCNT	0.49
CuZn30 (Brass)-0.99%MWCNT	0.39

Hardness

From the table 5 it is observed that hardness of CuZn30 (Brass) increases as percentage of MWCNT increases. This increase in hardness is due to increase in percentage of carbon.

Table -5 Hardness in HRE

Composite	Centre	Edge	Edge	Avg.
CuZn30 (Brass)	84	70	74	76
CuZn30 (Brass)-0.33%MWCNT	87	78	82	82
CuZn30 (Brass)-0.66%MWCNT	89	80	85	84
CuZn30 (Brass)-0.99%MWCNT	91	85	88	88

CONCLUSION

(1) Powder metallurgy process followed by mechanical alloying is successfully applied to synthesize CuZn30 (Brass)-MWCNT Nano composites.
(2) Mechanical alloying through high energy ball milling helps to improve homogeneous mixing and reduces the agglomeration of MWCNTs within the CuZn30 (Brass).
(3) The micro hardness have revealed enhanced mechanical properties of CuZn30 (Brass)-CNT composites due to the effect of mechanical alloying through ball milling.

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