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Mechanical Behaviour of Powder Metallurgy based Copper Reinforced with Nano Sic

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Abstract— **This project comprises of manufacturing copper metal matrix composites reinforced with nano SiC using powder metallurgy process to increase the mechanical properties like hardness, porosity and wear resistance. In this powder metallurgy method, the SiC particulate -reinforced copper composites were prepared by compacting and then by conventional sintering. The copper is selected as metal matrix composites for its high hardness, high strength and good wear resistance. The mixtures of powders are compacted at 600 Mpa, and sintered at 900^{0}c in the furnace. The density, hardness, strength and micro structures were investigated on the metal matrix composites. The SEM studies show the uniform distribution of silicon carbide over the copper matrix and XRD analysis represents the presence of Cu and SiC in the composites. The physical and mechanical properties of the copper SiC metal matrix composites are determined using compression, ring compression method and micro-hardness test. During this investigation both ductility and brittle nature were also examined. The idea of this project is to reinforce the SiC with the copper as per proportion tabulated for producing metal matrix composite which can be most applicable metals in the industries.**

Keywords— Reinforcement, powder metallurgy, SEM, ring compression test.

I.INTRODUCTION

Copper possess high strength, good wear resistance, excellent current and thermal conductivity than other metal, like iron & Al. Hence it's been widely used in today's manufacturing field for production of unique parts. The material such as silver, gold having physical properties higher than that of copper, but were not economic when compared to its cost for utilizing in manufacturing sector[1].Copper having high melting point of 1050^{0}c could be heated up to 950^{0}c which enables the criteria of blending the shape of copper to appreciated forms. The cables, wires and electric contacts which is used to pass current in between the appliance are extensively made from copper[1].Copper is also used as heat sink to remove heat from hot spots quickly[7].Elemental powders like copper are more compressible which produce compacted objects with good strength. The aerospace auto motive drive shafts, ground vehicle brake rotors and explosive engine components widely use copper [4]. As the machined product are facing so many problems during the mechanical operations. Like cracks, breakages, tool wear cause the major issue in reduction of product life. Hence of the powder metallurgy are best suited methods to enhance the wear, strength, toughness properties of material, by reinforced with most particles such as SiC, Al_2o_3, WC, SiO_2 etc.

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 produce thedesired product. Powder metallurgy is most advantageous since, it make use of raw materials without any wastage as scrap during the process. The economical mass production can be performed better by powder metallurgy process. In the powder metallurgy process the following three steps are followed in sequence namely the mixing (blending), compacting, and sintering. Industrial applications of powder metallurgy parts are several which include self lubricating bearings, porous metal filters and a wide range of engineered shapes such as gears, cams, brackets, sprockets, etc. By introduction of dispersoid particles in copper matrix will increase the mechanical strength dramatically which are known as reinforcement [1].The reinforcement is a main criteria that has been introduced in powder metallurgy to strengthen the manufactured parts. Silicon carbide is comparatively high than aluminium oxide in physical properties (stiffness, improved wear resistance) and low when compared to tungsten carbide, yet SiC used for its economic cost as tungsten carbide being costlier [3].There will be a significant improvement in the mechanical properties when copper was incorporated with particulate reinforcement such as SiC [6].The application of Cu-SiC matrix are used in preparing automobile parts and also used in spacecraft. SEM, XRD, EDS, micro-hardness test and ring compression test were conducted on Cu-SiC matrix to study its micro-structural characteristics and mechanical properties. The objective of this project is to produce copper by reinforcing with nano SiC which ought to be utilized in making components of high strength and good wear resistance.

II.EXPERIMENTAL DETAILS

A) Introduction:

Powder metallurgy is the process of blending fine powdered materials by pressing them into a desired shape or form (compacting), and then heating of the compressed material in a controlled atmosphere for a proper composite 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. The use of powder metal technology bypasses the need to manufacture the resulting products by metal removal processes, thereby reducing costs.

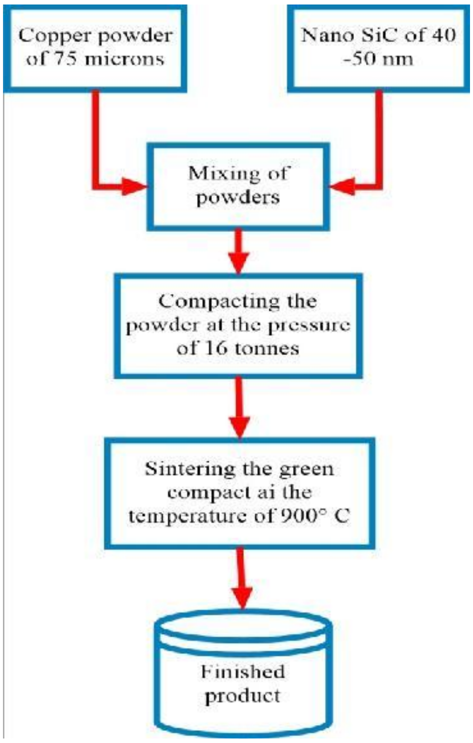

Fig .1. Flow chart of powder metallurgy process.

B) Fabrication of Die:

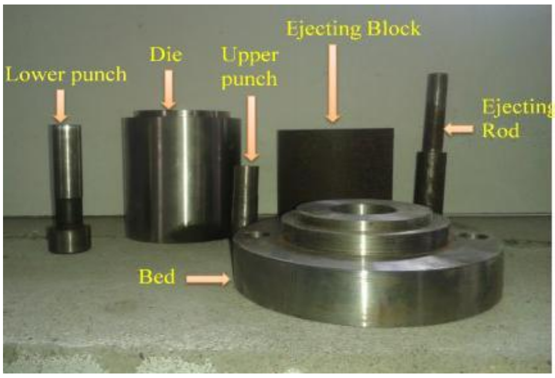

Fig .2.Photograph of the Fabrication die

Fig.2 shows that parts of the die which was fabricated for the present project work most basic consideration is being able to remove the part (billet) from the die after it is pressed, along with avoiding sharp corners in the design. Die consist of two punches namely the upper and lower punch which are positioned at compacting machine(UTM) for compaction of powder material to the required shape.

C) Compaction:

The Powder compaction is the process of compacting metal powder in a die through the application of high pressures using compacting machine. The metal matrix composite of copper is reinforced with 0%, 2%, 4%, 6%, 8% and 10% of SiC particles. The density of the compacted powder is directly proportional to the amount of pressure applied. There are four major classes of tool styles: single-action compaction, used for thin, flat components; opposed double-action with two punch motions, which accommodates thicker components; double-action with floating die and double action withdrawal die. Double action classes give much better density distribution than single action. But the punch adopted here is single punch since the size of the billet which was manufactured for testing is flat billet. Tooling must be designed so that it will withstand the extreme pressure without deforming or bending. Tools must be made from materials that are polished and wear-resistant. Filling a die cavity with a known volume of the powder feed-stock, delivered from a fill shoe followed by compaction of the powder within the die with punches to form the billet.

D) Sintering:

Sintering is the process of compacting and forming a solid mass of material by heat and without melting it to the point of liquefaction. Heat treatment process is done to bond the metallic particles, thereby increasing strength and hardness.

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Usually it is carried out between 70% and 90% of metal's melting point. However, the hardness of the sintered part increases remarkably the density of the sintered part becomes smaller than that of the green compact [9]. Once compacted into the mould the materials is placed under a muffle furnace for a period of time (six hours) and maintain the temperature of 900° C and then it is left for cooling naturally. Under heat, bonding takes place between the porous aggregate particles and once cooled the powder has bonded to form a solid component. And the green compact is kept inside the muffle furnace with the help of silica crucible.

Once compacted into the mould the material is placed under a high heating furnace for a period of six hours and then it is left for cooling naturally. Under heat, bonding takes place between the porous aggregate particles and once cooled the powder has bonded to form a solid component. The hardness of copper-SiC bonding increase with increase in temperature. The critical loads were the one that causes severe wear increases with the reinforcement content at high temperature.

E) Preparation of sample

Polishing is defined as the process of making the fine surface of the specimen performed after manufacturing of that using specimen polishing methods. It is the most important step in preparing a specimen for micro-structural analysis. It is the step which is required to completely eliminate previous damage. After the completion of sintering process the billets are polished by two methods

- Rough polishing.
- Fine polishing.

Rough polishing is the method in which the billets are rubbed in the various scales in emery sheets by rubbing the billets into horizontal and vertical direction. After completion of rough polishing the billets are rubbed in a specimen polishing machine for getting fine polishing for micro-structural analysis. The billets are dipped in the distilled water for viewing the clear surface and then the alumina paste is applied to the billet and the surface of polishing machine. And the fig.3 shows the billets of different compositions having fine surface for the micro-structural analysis.

Fig .3.Sample of different composition

III.TESTING DETAILS

A) Scanning Electron Microscope (SEM) analysis:

Scanning electron microscopy (SEM) uses a focused electron probe to extract structural and chemical information point-by-point from a region of interest in the sample. The high spatial resolution of an SEM makes it a powerful tool to characterise a wide range of specimens at the nanometre to micrometre length scales.

TABLE.1. PERCENTAGE COMPOSITION OF Cu & SiC IN SIX SAMPLE

Sl no	Sample name	Composition of Cu	Composition of SiC
1.	11A	90%	10%
2.	12A	92%	8%
3.	13A	94%	6%
4.	14A	96%	4%
5.	15A	98%	2%
6.	16A	100%	0%

B)Micro-hardness test

The term Micro Hardness Testing usually refers to static indentations made by loads of 1kgf. or less. The Baby Brinell Hardness Test uses a 1mm carbide ball, while the Vickers Hardness Test employs a diamond with an apical angle of 136°, and the Knoop Hardness Test uses a narrow rhombus shaped diamond indenter. The test surface usually must be highly polished. The smaller the force applied the higher the metallographic finish required. Microscopes with a magnification of around 500x are required to accurately measure the indentations produced. From six to four indentations were made for each sample. According to the reputability of the reading and an average of these reading was calculated. The position of indentation in the sample was chosen randomly in the sample to take in consideration the effect of present of two distinct materials the matrix and the reinforcement.

C) Ring compression test

The method of free ring compression is the most widely applied method for determining contact conditions in bulk forming processes; therefore it is treated as the standard, universal method for determining coefficient / factor of friction. And the hole is made on the surface of the billet by the help of the 10 mm drill bit in the drilling machine. The billet is compressed with the help of the Universal Testing Machine [UTM] for the time period of 1minute.

CONCLUSION

This paper as highlighted the mechanical parameters like high hardness, high strength and good ductility of the powder metallurgical produced pure copper reinforced with nano SiC .The grain and density factor are obtained from micro structural study .Hence the proper bonding of nano SiC to the copper particles at required level increases the properties of the billet to extent that are required for industrial applications. The sintering are ought to be done accordingly to the copper recommended temperature scale for avoiding dis appropriate mechanical failures.

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