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Critical study Investigation on Properties and Characteristics of Mechanical Composites in Copper

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Abstract— In this research, copper matrix composite reinforced with 5, 10 and 15 Vol. % SiC particles was fabricated via stir casting method. Pure atomized copper powder and Silicon carbide particulate with an average particle size 30 nm (99.9% purity) was used as reinforcement to fabricate Cu-SiC composites at casting temperature (8500C) and stirring periods(2 and 6 min). Optimum amount of reinforcement and casting temperature were determined by evaluating the density, microstructure and mechanical properties of composite. The composite were characterized by scanning electron microscopy (SEM). Hardness test were carried out in order to identify mechanical property. A good distribution of the dispersed SiC particulates in the matrix alloy was achieved.

Keywords: ***Cu/SiC composite, Friction Stir Processing, Wear, Scanning Electron Microscopy***

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I. INTRODUCTION

Due to low mechanical strength, a highly conductive copper matrix needs to be dispersion strengthened and new composite materials with superior characteristics have been developed [2]. Fine microstructure and absence of casting defects are the main advantages of FSP [1]. Cu–SiC composites combine both the superior ductility and toughness of copper and high strength and high modulus of SiC reinforcements [5]. They are feasible to be used as electrical contact materials in relays, contactors, s witches, circuit breaks and other switch gear components [6]. good resistance to oxidation and corrosion [7] and a special position between all metals because of its electrical and thermal conductivity. So, the most general application of Cu is where high electrical and thermal conductivity are needed [8]. Low strength and poor wear resistance are the major limitation of Cu and its alloys. SiC has high chemical and low electrical resistance. In the Mohs-hardness scale, the hardness of SiC is between corundum and diamond [3, 7]. FSP is a technique for fabrication of Metal Matrix Composites (MMCs) that exhibit good wear re sistance and high hardness [9] and have improved resistance to creep and fatigue, but because of non-deformable ceramic reinforcements, MMCS haven't good ductility and toughness. In this study, In order to perform this, an attempt was made to fabricate Cu composites reinforced with SiC particles by means of stir casting process and to study the effect of sintering temperature on mechanical and electrical properties of composites. The morphology, microstructure, and micro hardness of Cu/SiC composite are investigated and the relationship between the microstructure and performance of the composite is also analyzed.

II. RELATED WORKS

Grinded copper powder (99.95 wt.% Cu) less than 5000 nm in size used as initial base materials. SiC particles (60µm) were used as reinforcement. The surface of plates was cleaned by acetone before FSP. In order to fabricate the composites, 1 g reinforc ement SiC powder was encapsulated carefully in an copper foil packet for insertion into the molten Copper in order to fabricate a composite with 5,10,15 wt% SiC as reinforcement. These powders were preheated at 350 C for 4 h before the casting process to remove the moisture and impurities. The pure copper was heated to the temperature of 850 C within a bottom-pouring furnace. The process experiments were performed using a vertical milling machine and the Bohler shoulder with a cylindrical-cone pin shape with given dimension. The tool was tilted 3º from the plate normal direction. According a net of holes was designed on surface of plate, and the SiC was located into them before processing.

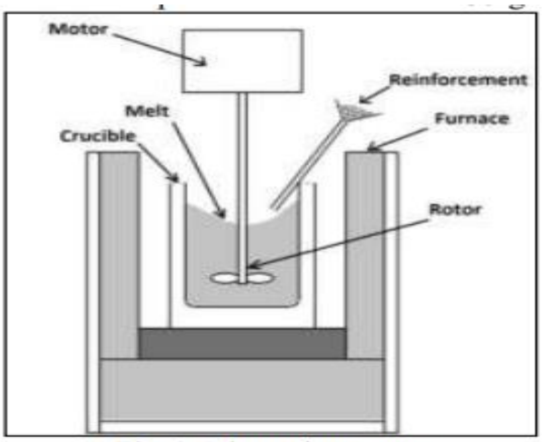

Fig. 1: Stir casting set up

THE CONSTANT ROTATIONAL AND TRAVEL SPEEDS WERE 1000 RP M AND 50 MM/MIN, RESPECTIVELY COMPOSITE SLURRY WAS POURED INTO A LOW-CARBON STEEL MOLD. 1 WT% MG WAS ADDED TO THE MELT TO NCREASE THE WET ABILITY BETWEEN THE MATRIX AND THE REINFORCEMENTS, MG ACTS LIKE A SURFACTANT POWER, WHICH REDUCES THE COPPER OXIDE COATING BY BINDING TO THE OXYGEN. THE MICROSTRUCTURE OF SPECIMENS WAS EXAMINED BY SEM ANALYSIS WAS USED TO EVALUATE THE PHASE COMPOSITION. MICRO HARDNESS MEASUREMENTS WERE PERFORMED AT A LOAD OF 50 GR AND DWELL TIME OF 15S.

III. METHODOLOGY

Relative Density, Hardness Relative densities of Cu and Cu–SiC composites, at 8500 0C , determined by using Archimedes's principle, increment in the casting temperature caused the decrease in the relative density of the samples. This is due to the density of SiC particles being muc h lower than that of copper. In composite with low SiC volume fraction, less Cu–SiC interface means less copper atom diffusion barrier, copper atoms can diffuse readily and fill the interstices between the SiC particles, thus leading to a higher densification o f the composites. Hardness is termed as indentation resistance or snatch. Hardness values were determined by taking the average of three different measurements on each sample. The hardness of Cu and Cu–SiC composites were given in Table 1. Hardness of the samples generally decreased with increasing sintering temperature. This may result from the increase of the grain size. The hardness of pure copper casted at 8500C is 126 HV for and increased to 149 HV with increasing SiC content. These values are quite bigg er than that of pure copper having hardness value of 37 HV. It is well known that, the hardness of ductile copper can be improved by dispersion of second hard phase. It is thought that higher amount of the ceramic particles in the matrix results in more dislocations, and as a result, the hardness of the composite increases. T

IV. RESULTS AND DISCUSSIONS

Table – 1
The hardness of Cu and Cu–SiC composites

SiC(wt.%) Properties	Relative density (%)	Hardness (HVN)
0	98.2 ± 1.2	126 ± 2.1
5	92.0 ± 1.5	149 ± 3.1
10	87.4 ± 1.8	187 ± 4.1
15	81.2 ± 2.1	223 ± 5.1

Among the various hardness measurements, the Rockwell hardness test was significant. Because for the with pure Cu(99.9%), Table.(2), binder sample advertised hardness as 18 HRB, not greater than the 85 HRB obtained for pure Cu, increases due to bonding effect of SiCp to impart higher hardness. To improve the hardness, good quality interface characteristics reinforceme nts are increased with Cu.

Table – 2
Presentation of Rockwell hardness test values of Cu-SiC composite

Composition of matrix (Wt. %)	Rockwell hardness (HRB)
Pure Cu 99.9%	8 ± 1.3
Cu-5% SiC	85 ± 1.4
Cu-10% SiC	96 ± 0.8
Cu-15% SiC	102 ± 1.2

The hardness of casted compacts increased slightly with amount of reinforcing SiC. The hardness of material is a physical parameter indicating the ability of resisting local plastic deformation. SiC with high hardness, which act as reinforcing pha ses, are dispersed in copper matrix and become the obstacles to the movement of dislocation when plastic deformation occurs, and resulted in the distortion of lattice, which created much internal stress in composites. The BHN is evaluated by pressing small standard steel balls (D = 2.5 to 4.75 mm diameter) into a surface of the test metal with a force (P = 90 kg of load) on those balls such that it makes a little circular indentation (diameter d mm). Table 3 represent the Brinell hardness values for Cu-SiC Composites.

Table – 3
Presentation of Brinell hardness values for Cu-SiC composites

Composition Cu-SiC (wt%)	Brinell Hardness (HBN)
Pure Cu (99.95%)	35
Cu-5% SiC	108
Cu-10% SiC	119
Cu-15% SiC	128

B. Microstructures SEM micrographs of starting powders are given in Figs. 1 and 2.

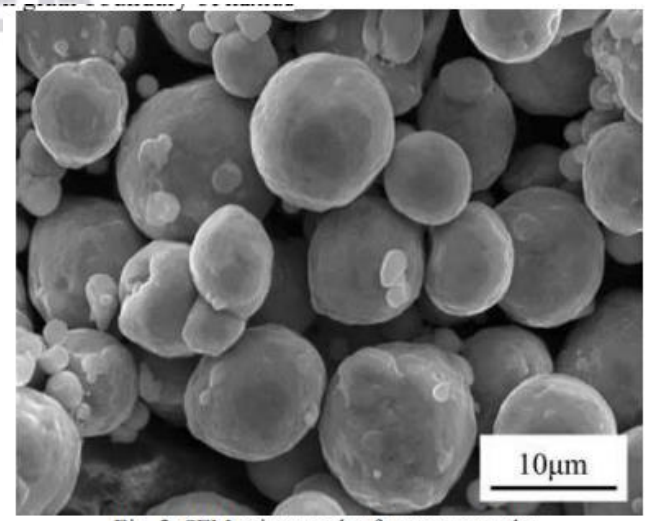

Fig. 2: SEM micrograph of copper powder.

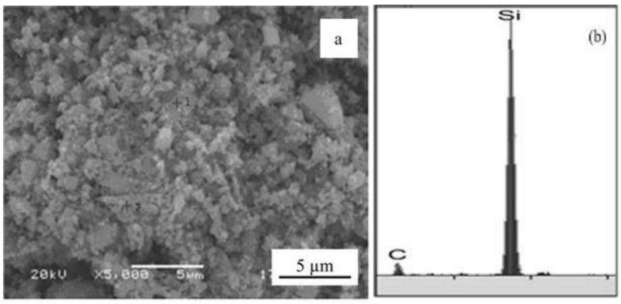

Fig. 3: (a) SEM image and (b) EDS Analysis of SIC Powder

Figure 3 (a) and (b) represents the SEM image and EDS Analysis of SIC Powder. The microstructure of Cu-SiC alloy, in as cast condition, shows the dendrites of copper and eutectic silicon in the interdendritic regions and around the dendrites. A higher magnification micrograph Cu composite alloy in as cast condition shows sharp-edges plate-shaped silicon in copper matrix. The micrograph of Cu composite - 15 wt. % SiC composite, in as cast condition, shows uniform distribution of SiC particles in copper matrix. A higher magnification micrograph of Cu composite - 15 wt% SiC composite shows good interfacial bonding between coppermatrix and silicon carbide particle. Figure 4 (a) and (b) represent the graphical statement of composition with hardness and composition with density

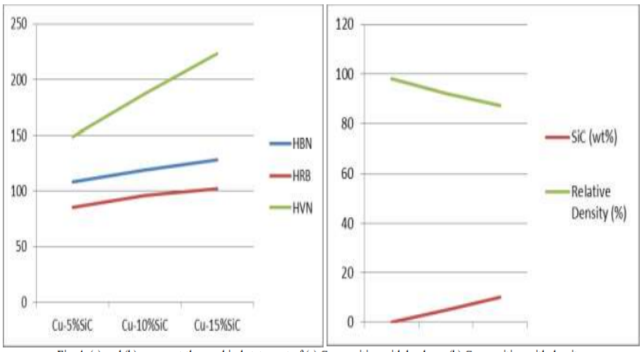

Fig. 4: (a) and (b) represent the graphical statement of (a) Composition with hardness (b) Composition with density

V. CONCLUSION

In this experiment, microstructure and properties of Cu/SiC composite were investigated. The following conclusions can be made: – Cu and Cu–SiC composites reinforced with 5wt.%, 10wt.%, and 15 wt.% particles were produced by stir casting method successfully. – SEM studies reveal that it is clear that SiC particles are homogeneously distributed and dominantly occupy around copper grains. – Hardness of composites was increased as the sintering temperature and the amount of reinforced particle increased. – In comparison to pure Cu, Cu/SiC composite shows higher hardness and better microstructure. – It is to believe that with SiC addition to copper supplying electron distortion, the electrical conductivity decreased.

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