ABSTRACT

Silicon carbide-Tungsten carbide fiber - reinforced with OFHC copper matrix has its utilization for many electrical contacts and electrode materials in machining process for its high purity and thermal conductivity. This paper is fully based on the fabrication of powder metallurgy route in the primary stage, used to determine suitable mixing time, high compaction pressure, sintering process, corrosion resistance, selection of matrix and reinforcements of Cu-WC-SiCp matrix composites arranged for compaction process in powder metallurgy. The wear resistance of OFHC Cu/WC-SiCp composites are inspected scratch test, pin-on-disc wear test, hardness measurement and correlated with that of governing materials. WC-SiCp boosted the overall wear performance by 54% under a normal load of 48 N and at a sliding distance of 12.5 m/s which support the strengthening property of the OFHC Cu matrix. The Fragmentation, of WC-SiCp energized particles seem to be the important wear mechanisms of Cu/WC-SiCp complex under sliding wear. In this review article, improvements were concentrated in the fabrication of reinforced Cu metal matrix and properties of the Cu composites reinforced of ceramic metal carbides will be nourished. To understand the wear mechanism, optical microscopy and SEM analysis must be drifted.

KEYWORDS: OFHC Cu powder, WC/SiC, Microstructure, Wear test, Powder Metallurgy, UTM.

1. INTRODUCTION

The two outstanding essentials of composite material are the matrix material and the coating material. The manageable support for reinforcement is given by OFHC, which is usually a heavy metal matrix in structural applications. The coating does not always give formalistic work (reinforcing the compound), on the other hand it is helpful in changing the physical properties such as wear resistance, frictional coefficient and thermal conductivity. In the present technical side, the demand for electrode materials and tool cerments carbide has grown. This is because these types of MMCs have good strength to weight ratio, high modulus rigidity, excellent thermal expansion and good tribological properties.

In the current scenario, larger flaws and more errors are expected to occur in larger particles and, therefore, will crumble the strength of composites in comparison with the composites containing smaller particles. The composites of shorter grain size contain smaller reinforcement particles can also afford to the increase in strength.

On the other hand, the high percentage of metal particle reinforcement phase(s) of PRMMC which is unusual, can be achieved by favorable combinations of strength and resolution when processed appropriately [7,11]. Among an array of available high-volume PRMMCs excellent mechanical properties are given by tungsten carbide reinforcement [3]. For the following reasons tungsten carbide particles reinforced with copper alloy is used particularly. Firstly the bond between the matrix and the reinforcing phase must be excellent and also good compatibility with each other [8,12].

Secondly, when reinforced with hard ceramic particle such as tungsten carbide and silicon carbide sustainable wear resistance was exhibited by copper based alloy composites [2]. Thirdly, tungsten carbide and silicon carbide maintain the thermal conductivity property at room temperature upto 1550°C without any changes in phases [2]. The current work reveals the improvement of overall hardness due the effect of Cu alloy-WC-SiCp composites which was built up by compaction and sintering process.

2. EXPERIMENTAL SETUP:

In this study, MMC EDM electrodes are provided by two variable routes. To determine the best composition ratio and best sintering temperature powder metallurgy was using a basic course. The experimental flow chart is shown in figure (2).

![Fig. 1. Schematic diagram of a Cu alloy based composite reinforced with tungsten carbide and silicon carbide particles.](image1)

![Fig. 2. Experimental Flow Chart for powder metallurgy](image2)
were removed from the furnace immediately after preheating and poured into respective die for compaction process. Electrical discharge machining method was used for the mechanical testing properties. Finally microstructural characterization was achieved by etching of nitric acid solution.

### Table (1): Physical Properties of OFHC Cu, SiC & WC

<table>
<thead>
<tr>
<th>Material</th>
<th>Melting Point °C</th>
<th>Boiling Point °C</th>
<th>Density, g/cm³</th>
<th>Mohr Hardness @ 20°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFHC Cu</td>
<td>1083</td>
<td>2595</td>
<td>8.94</td>
<td>3.0</td>
</tr>
<tr>
<td>Tungsten Carbide</td>
<td>2830</td>
<td>5890</td>
<td>15.63</td>
<td>9.0</td>
</tr>
<tr>
<td>Silicon Carbide</td>
<td>2730</td>
<td>-</td>
<td>3.21</td>
<td>9.9-5</td>
</tr>
</tbody>
</table>

#### 2.2. Powder Metallurgy process:
To allow the bonding of materials, metal powder is heated below its melting point in a controlled atmospheric pressure. In order to improve their mechanical properties, the mixed OFHC copper powder were sintered. To regulate the optimum sintering temperature, sintering was done in open hearth or fire furnace for 90 minutes at 870 °C, 940 °C and 984 °C which were 80, 85 and 90 % of the melting temperature OFHC copper respectively.

#### 2.3. Materials and Preparation:
OFHC Cu(99.95%) powder of particle size of < 76 µm and WC SiC powder of particle size 47 µm were taken. The powders were prepared by mixing the Cu powder with 10, 15, 20 and 25 mass% of WC -SiC powder in a ball mill 6 hours. Increase in 1.8 % of weight SiC and the increase in 5 % of weight WC of the total weight of OFHC Cu mixtures were considered in the compaction process. In ball mill operators, the mixing ratios of powder materials are processed for about 30 minutes at 110 rpm to check the powders are well blended. Table (2) shows the mixing ratio of component materials that were used in this study.

### Table (2). Mixing Ratios of composition matrix materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Composition of matrix (Wt. %)</th>
<th>Rockwell hardness (HRB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFHC CU</td>
<td>Pure Cu 99.9%</td>
<td>8 ± 1.3</td>
</tr>
<tr>
<td>OFHC Cu-alloy</td>
<td>80Cu–5WC–15SiC</td>
<td>85 ± 1.4</td>
</tr>
<tr>
<td>OFHC Cu-alloy</td>
<td>80Cu–7.5WC–12.5SiC</td>
<td>89 ± 1.7</td>
</tr>
<tr>
<td>OFHC Cu-alloy</td>
<td>80Cu–10WC–10SiC</td>
<td>96 ± 0.8</td>
</tr>
</tbody>
</table>

#### 2.4. Compaction Process:
High strength was required to form definite shapes from metal powders by the processes of compaction. The definite shape was obtained by forcing the heated metal powder in an die (OHNS) under uniform high pressure. After compaction was done, the work part is called as green compact or simply a green [6,11]. The powder after being heated were replaced into an OHNS die. It has both punch and dummy piece. The punch serves two purposes, to apply load to a heated powder in a die for compaction to take place and to take work part from the die. The lubricant Zinc stearate were used on the inner walls of the die. The tool was taken out of the die safely once the composites were allowed to cool below its room temperature. The function of zinc stearate is to prevent the sticking of powder mix to the inner surfaces of the die.

Sufficient quantity of heated powder measured by its weight were taken from the crucible and discharged into the die with its butt or dummy piece at the end. A punch was imported into the die and load enforced to the punch, thus by assigning the die inside the universal testing machine (400 KN) which operates hydraulically [9]. The heated powders were pressed at 45 KN respectively to attain a long cylinder rod of diameter measuring 15 mm. The butt were ejected out from a die after compact and the die were placed over two parallel blocks having same height, the hole was left out between the blocks and then the pressure was applied into the punch.

### Fig. (4): Powder Pressing process in UTM.

#### 3. RESULTS AND DISCUSSION

### 3.1. Microstructure:
The micrographs of etched powder mix to the inner surfaces of the die. The tool was taken out of the die safely once the composites were allowed to cool below its room temperature. The function of zinc stearate is to prevent the sticking of powder mix to the inner surfaces of the die.

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### Fig. (4): Powder Pressing process in UTM.
The point of contact area samples than the solid surfaces. The apparent area of contact is comparatively smaller than the solid surfaces.

3.3. Wear Resistance: Being specified to the point of contact area between the surface asperities, the apparent area of contact is comparatively smaller than the solid surfaces. The surface area of composite samples to which the load applied are transferred to the point of contact area and to which Normal force applied to the level surfaces becomes quite large. From Fig.(7), the overall wear behaviour of Cu composite must be analyzed and monitored for reinforcing phases and for metal matrix. The possible betrothment of WC-Sicp in wear course precisely affects the overall strength of wear due to indentical properties between OFHC Cu/ WC-Sicp phases. The frictional coefficient for the composites remains doudful for the primary sliding distance of 250 m. Till the end end of the test, they were maintained in a steady state. The surface roughness of 1 µm [9] were influenced by frictional behaviour of metal composites. While carrying out the wear test, the oxidative wear should be minimum in OFHC Cu because it affects the mechanical properties of materials [13].

Fig.(5). SEM micrographs particle-matrix interface between the OFHC Cu matrix / WC- SiCp for different magnification factor

3.2. Hardness Measurement: Hardness is termed as indentation resistance or snatch. Among the various hardness measurement, the Rockwell hardness test was significant. Because for the both composite materials and binder with pure Cu(99.9%), Table.(2), binder sample advertised hardness as 18 HRB, not greater than the 85 HRB obtained for pure annealed Cu, increases due to bonding effects of WC and SiCp to impart higher hardness. To improve the hardness, good quality interface characteristics reinforcements are coated with OFHC Cu [14].

Fig.(6). Plots of Graph between Hardness (Vs) Volume

Focussing on other combinations ratios of composite samples, [89-91HRB] and [96-98 HRB] laid out a higher hardness than compared to previous one, which abruptly increases the strengthening effect of OFHC Cu matrix composites. Moreover, due to the superior hardness and heat resistance characteristics of the particles that are dispersed in the matrix exhibit excellent wear resistance [11-12]. SiC being a ceramic material, when incorporated with Cu, hardness has been improved by means of particle size, which boost the load carrying capability of the composites [10]. A good agreement exists between the hardness value of the composite materials which were being referred from literature for other similar composite materials.

4. CONCLUSIONS:

By sintering and compaction fabrication was being employed for WC-Sicp reinforced with OFHC Cu composites through powder metallurgy techniques. Speculative conclusion reveals that wear resistance and thermal property of the sintered composite decreased nearly with increasing WC-Sicp content. The following conclusions can be drawn from this study:

1. In Micrographs, the analysis concede an orderly distribution of WC-Sic particles in OFHC Cu matrix with nominal cracks at the interface between the binder and matrix. Pin-on-disc test were executed to resolve the correlation between the wear behavior.

2. In SEM observation of worn surfaces and wear particles, contrast differences between low and high wear. A wear mode map revealed that large brittle fracture on copper matrix caused the significant increase of specific wear rate.

REFERENCES:
