International Symposium of Research Students on Materials Science and Engineering
December 20-22, 2004, Chennai, India
Department of Metallurgical and Materials Engineering, Indian Institute of Technology Madras

TRIBOLOGICAL PROPERTIES OF CAST COPPER-SiC-GRAPHITE HYBRID COMPOSITES

R.Noor Ahmed and C.S.Ramesh
Ghousia Research Centre, Ghousia College of Engineering, Ramanagaram-571511.

ABSTRACT

Since ages, copper and its alloys have found extensive applications in manufacture of bushes and bearings, heat transfer conductors, high conductivity electrical contactors and so on. However, currently, in all these applications, there is a significant enhancement in the service loads, wear resistance, conductivity thus forcing the material researchers to develop a newer class of copper based advanced materials. In this direction, researchers have focused their attention on improving the strength and the tribological properties by reinforcing copper with hard ceramic reinforcements such as Silicon carbide and Titanium carbide. The major drawbacks of these copper based composites are reduced conductivity and poor machinability. These two are the major factors that strongly influence the popularity of the developed copper based composites in several technological fields of applications. To overcome this, efforts are on to make use of a soft phase such as graphite as a additional reinforcement to the conventional copper based hard reinforced composites. Graphite being a solid lubricant can improve the machinability of the composites. Furthermore, graphite possess excellent thermal and electrical conductivity thereby, can improve the conducting capability of copper composites. In the light of the above facts, this paper aims at discussing the tribological characteristics of cast copper-SiC-graphite hybrid composites. Cast Copper-SiC-Gr Composites have been developed successfully by liquid metallurgy route. The hard reinforcement SiC of 3, 5 & 10 wt% has been dispersed along with soft reinforcement graphite of 1 wt% in high purity copper scrap. The cast Cu-SiC-Gr composites have been subjected to microhardness, friction & wear tests. Metallography studies have revealed uniformity in distribution of reinforcement in the matrix metal. Increased content of SiC in the hybrid composite has resulted in better wear resistance of the hybrid composites. Presence of graphite in the hybrid composite has resulted in lowering of coefficient of friction of hybrid composites when compared with Cu-SiC composites.

Keywords: Hybrid composites, copper, silicon carbide, graphite.

1. INTRODUCTION

In recent years, copper based composites are gaining wide spread importance in several high tech applications [1-3]. The mechanical properties of copper based conventional composites involving a single reinforcement have been studied [4]. Use of single reinforcement in copper may sometimes lead to the deterioration in the values of its physical properties. To overcome this, the concept of use of two different types of reinforcement are being tried out in copper matrix . Hard reinforcements such as SiC will enhance the hardness and abrasive wear resistance of copper while it has a negative effect on the machinability and conductivity of copper. To offset these effects, graphite being a solid lubricant and possessing good conductivity can be dispersed in copper along with SiC. However, meager information is available as regards the processing and characterization of these novel hybrid copper composites. In the light of the above, the

present investigation is aimed at producing copper hybrid composites using pure copper as matrix and SiC and graphite powders as reinforcements.

2. EXPERIMENTAL DETAILS

Pure copper was melted using coke fired furnace and preheated silicon carbide and graphite powders in the weight ratios of 3:1, 5:1, 10:1 were added to the vortex of the molten metal. Stirring time adopted was 10 minutes. Degassing was achieved by use of commercially available degassing tablets. The composite melts were poured into preheated cast iron cylindrical moulds. Cast hybrid composites were then machined and subjected to metallographic studies, hardness, friction and wear tests. Friction and wear tests were conducted using a pin on disc machine. The specimen diameter was 10mm. Counter disc used was high carbon high chromium steel of hardness R_C 60 . Sliding speed was varied between 100 & 500 rpm (Sliding velocity of 0.3-1.5m/sec) while load was varied between 10-50N. The frictional force was recorded using a force transducer while the wear loss was measured in terms of height loss of the specimens using an LVDT

3. RESULTS & DISCUSSIONS

Fig.1 shows the microphotographs of cast copper and its hybrid composites. It is observed that there is a fairly uniform distribution of reinforcements in the matrix metal. The silicon carbide particles can be clearly identified when compared with graphite.

Fig.2 shows the variation of hardness of all the composites studied. It is observed that on addition of SiC to copper, there is an enhancement of hardness of copper composites. Use of graphite as an additional reinforcement to copper –SiC composites has lowered the hardness. The reduction in the hardness is not drastic. The hardness of the hybrid composites are lower than Copper-SiC while it is much higher when compared to copper and copper-graphite composite.

Fig.3 shows the wear loss with time for all the composites studied. Increased time has resulted in higher weight loss for all the materials studied. However, increased content of SiC in the hybrid composites has resulted in lower wear loss. The increased wear resistance of the hybrid composites when compared with pure copper can be attributed to the following reasons. Increased content of SiC a hard ceramic will result in enhancement in the hardness of the composites. Increased hardness leads to lowering of wear loss and seizing. Further, the presence of graphite in hybrid composites has further influenced the wear behaviour of it. Graphite, a solid lubricant will tend to get smeared out between the rubbing surfaces thereby minimizing the chances of three body abrasive wear that is normally encountered in conventional hard ceramic reinforced metal matrix composites. This phenomenon will drastically reduce the wear loss of the hybrid composites.

Fig.4 shows the variation of coefficient of friction of copper and its hybrid composites with time. It is observed that increased time results in higher coefficient of friction for all the materials studied. It is observed that increased contents of SiC in the hybrid composites has resulted in higher coefficient of friction. This can be attributed to inferior surface finish of the composites with increased contents of SiC.

Fig.5 shows the variation of coefficient of friction of copper and its hybrid composites with speed. It is observed that as the speed increases, the coefficient of friction increases for all the composites studied. However, copper-SiC composites exhibited the highest coefficient of friction , while copper-graphite system showed the lowest coefficient of friction. Copper-SiC-graphite hybrid composites exhibited coefficient of friction values which lie between those of copper-SiC & Copper-graphite composites. The lowering of coefficient of friction of the hybrid composites can be attributed mainly to the

presence of graphite which is a solid lubricant possessing a very low value of coefficient of friction of 0.1.

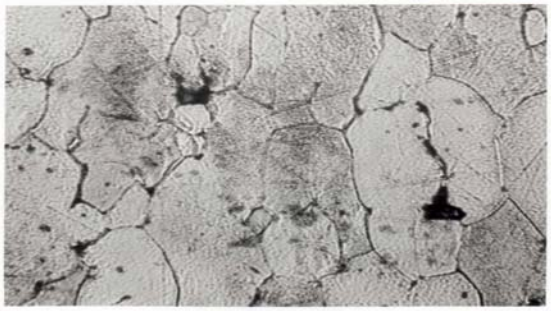
4. CONCLUSIONS

Hybrid copper-SiC-Graphite composites have been successfully prepared by liquid metallurgy route. The hybrid composites possess values of hardness, coefficient of friction in between that of copper-SiC and Copper-graphite composites but possess excellent wear resistance when compared with the monolithic composites.

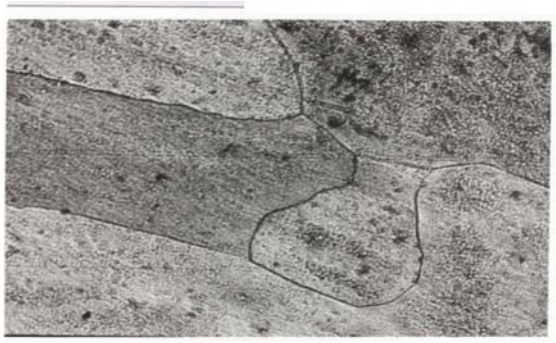
5. REFERENCES

1. C.S. Ramesh, Noor Ahmed.R & Mir Safiulla, 3rd International Conference on Advanced Manufacturing and Technology (ICAMAT) 2004, Kaulalumpur, 11-13 May 2004 P 836.
2. Rohatgi, Pradeep Kumar, Kim, Casting of copper alloys containing dispersed graphite particles in rotating moulds, Foundryman V91n, May 1998, P 167.
3. P.K. Rohatgi, S. Roy, AFS Transaction, volume 100, P1.
4. P.K. Rohatgi, J.K. Kim, Processing and properties of cast metal matrix composites, TMS material week, Cincinatty, OH, 1996, P 271.

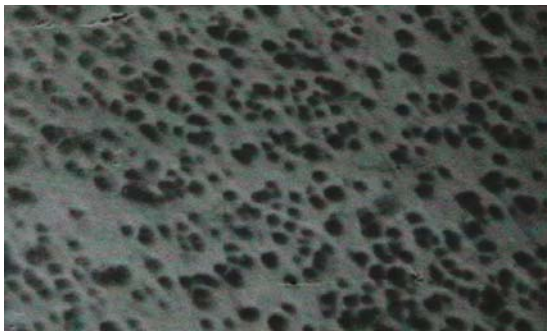
FIGURES



Copper



Cu – 3wt% SiC – 1wt% Gr



Cu – 10wt% SiC – 1wt% Gr

Fig.1.Microphotograph of Cu & its Hybrid composites

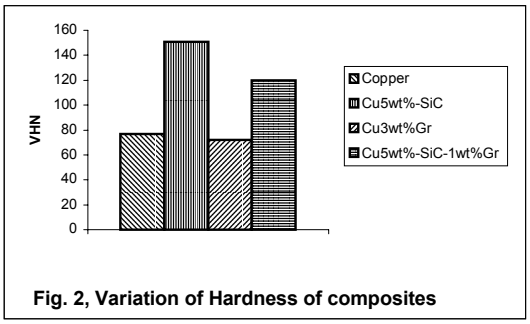


Fig. 2, Variation of Hardness of composites

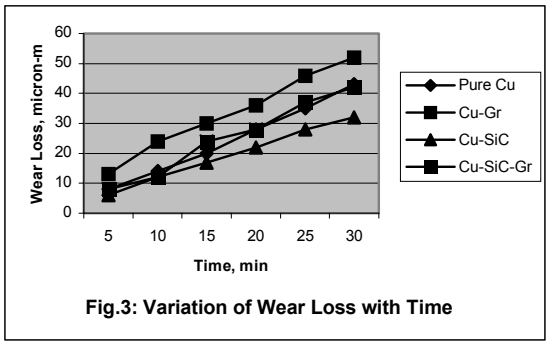


Fig.3: Variation of Wear Loss with Time

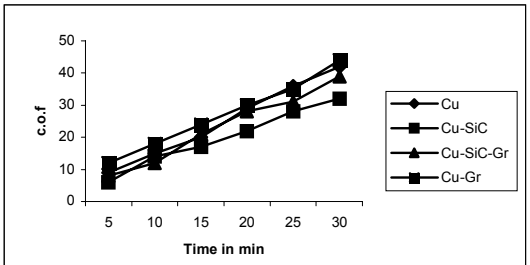


Fig.4,Variation of wear loss with time

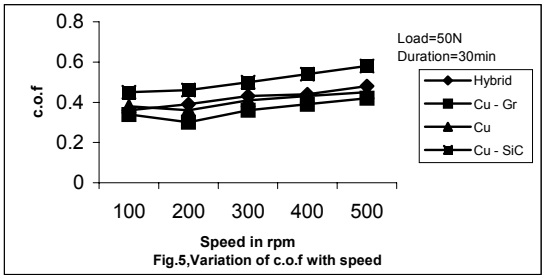


Fig.5,Variation of c.o.f with speed