ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

IJARMATE

International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. II, Issue IV, April 2016.

MECHANICAL CHARACTERIZATION OF COPPER-GRAPHITE METAL MATRIX COMPOSITE BY POWDER METALLURGY

[1]S.NOBLE, [1]R. CHRISTU PAUL

[1]Department of Mechanical Engineering, C.S.I Institute of Technology, Thovalai, Tamilnadu, India.

Abstract:

Copper–graphite metal matrix composites (MMCs) possess the properties of copper, i.e. excellent thermal and electrical conductivities, and properties of graphite, i.e. solid lubricating and small thermal expansion coefficient. They are widely used as brushes, and bearing materials because of the above properties. Copper-graphite with low percentages of graphite is also used for slip rings, switches, relays, connectors, plugs and low voltage DC machines with very high current densities. In the present investigation, attempts have been made for the fabrication of Cu-graphite MMC by conventional and spark plasma sintering (SPS) techniques. The MMCs were characterized by x-ray diffraction (XRD) and scanning electron microscopy (SEM). Different mechanical properties like density, bulk hardness and wear study were also conducted. samples show higher wear resistance than conventional sintered samples.

Keywords: Composite material; Copper matrix; Graphite particulate; Powder metallurgy

1. Introduction:

Composite materials are playing an important role in metal component manufacturing. Composite materials offer higher specific strength and stiffness than other conventional materials. Metal matrix can be prepared by using various techniques including powder metallurgy, molten metal and spray deposition. Composites can be used to make complex shape without using high pressure tools, because composite is formed when matrix goes solid. Composites are also highly resistant to chemicals and will never rust or corrode. Graphite particulate reinforced copper matrix is good example of composite material which is made using powder metallurgy process.

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

IJARMATE

International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. II, Issue IV, April 2016.

Copper–graphite metal matrix composites possess the properties of copper, i.e. excellent thermal and electrical conductivities, and properties of graphite, i.e. solid lubricating and small thermal expansion coefficient. They are widely used as brushes, and bearing materials because of the above properties. Copper-graphite with low percentages of graphite is also used for slip rings, switches, relays, connectors, plugs and low voltage DC machines with very high current densities. Properties of Cu-Graphite composites are it has a coefficient of thermal expansion between 4-6 ppm/ oC (depends on the temperature) and it is also have high resistance to thermal shock. In presented paper different weight percentage of graphite particulates are reinforced into copper matrix. Samples has been produced using powder metallurgy process. Microstructure and Brinell hardness test has been done for studying mechanical and physical properties.

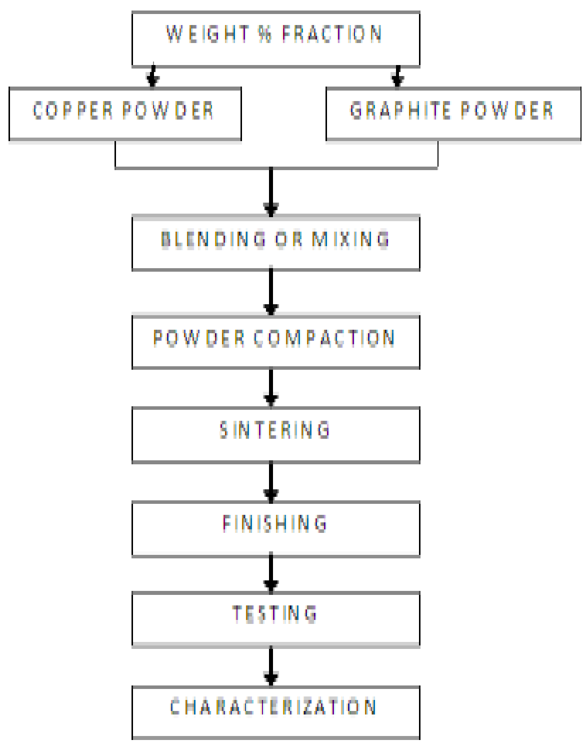
2. Experimental:

2.1 Material:

As received copper and graphite powders of 25g were mixed such that the volume fractions of graphite in the mixtures were 0% (pure copper), 1%, 3%, 5% and 10 % respectively. Then, the samples were taken and blended together properly using a pestle and mortar for 30 minutes to ensure uniform distribution of the graphite particles throughout the copper matrix. The blended samples were then cold compacted by applying a load of 700 MPa for 2 minutes in a die of 25 mm diameter.

2.2 Fabrication of composite:

Powder metallurgy technique has been used making composite, because high strength, toughness and ductility can be obtained for composite and another benefit is particulates can be easily reinforced into metal matrix.



Copper and graphite powder blended using mortar. Polyvinyl alcohol (PVA) is used as a binder. After blending compositions, a pellet

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

IJARMATE

International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. II, Issue IV, April 2016.

has been made using compaction process. Compaction pressure kept constant i.e. 150 Mpa. Two different sintering temperatures has been chosen for sintering process i.e. 8600C and 9000C. Each pellet was sintered for 1 hour. Finally finished product has made for characterization.

2.3 Study of microstructure and Mechanical property:

Study of microstructure of Copper-Graphite has been done using optical microscope of power AT 200X. Distribution of graphite particulates in copper matrix has studied using these microstructures. Brinell hardness test has done for studying mechanical properties. 100 Kgf load has applied to measure hardness of samples.

3. Results & discussion:

Optical microscope was used to study microstructure of developed composite. Fig (2-4) shows the microstructure images taken from optical microscope at 200X magnification of copper (100%) at 8600C, copper (95%)+ graphite (5%) at 8600C, copper (100%) at 9000C, copper (95%)+ graphite (5%) at 9000C samples. Distribution of Graphite particulates in Copper matrix is clearly seen in the images.

3.1 XRD Analysis:

XRD plots of copper-graphite composite samples with 0%, 1%, 3%, 5% & 10% by volume of graphite prepared by conventional sintering method are shown in figure 1.

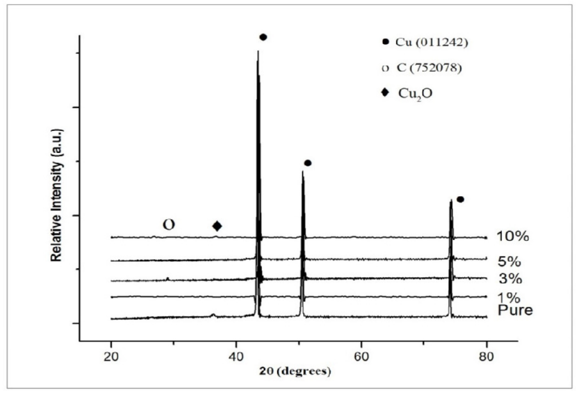


Figure 1: XRD plots of pure Cu, Cu- 1 vol. %, Cu- 3 vol. %, Cu-5 vol. % and Cu-10 vol. % graphite MMC sintered at 900°C for 1 hour.

From the graph, very distinct peaks of copper can be observed. Whereas feeble peak of graphite is observed as amount of graphite is very less as compared to Cu. Also, some amount of copper oxide is detected which is undesirable. It may have been formed due to the presence of atmospheric oxygen during conventional sintering in the tubular furnace. It is also seen that no reaction takes place between copper and graphite during fabrication of composites.

3.2 Hardness Measurement:

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

IJARMATE
International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. II, Issue IV, April 2016.

The Vickers hardness for different samples corresponding to conventionally sintered samples at 900°C with graphite of 0%, 1%, 3%, 5% & 10% by volume was recorded. The same was done for spark plasma sintered samples (1% & 5% by volume of graphite). The micro hardness of both set of samples was compared by plotting graphs between Vickers Hardness and varying composition of graphite as shown in figure 2.

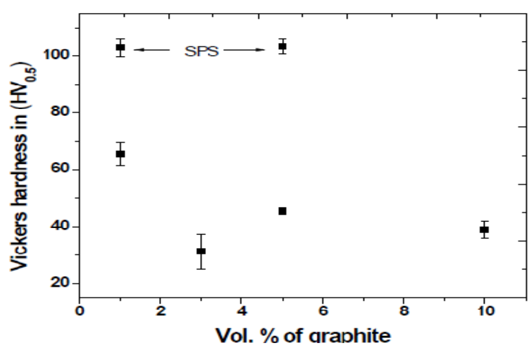


Figure 2: Variation in Vickers Hardness with volume % of graphite for conventionally sintered samples & SPS samples

The trend in the graph indicates that hardness of the conventionally sintered sample increases up to the presence of about 1% graphite and then decreases. This may be due to facilitation of agglomeration of softer graphite fines after the critical concentration is reached. Another factor that may have contributed to the increase in the hardness initially is the effective dispersion strengthening by the introduction of graphite particles in the copper matrix.

As expected, the spark plasma sintered sample has a much higher hardness value (in the range of 100 H_v) than the conventionally sintered sample. Better dispersion of graphite in copper matrix may have led to small-scale pinning in the composites, thus preventing grain growth and increasing hardness. Another reason for the high hardness in SPS samples may be owed to the fact that sintering occurs at high pressures that results in superior compaction. Also the hardness values of the SPS sample remains almost constant as we increase the graphite volume content from 1% to 5%.

3.3 SEM Analysis

SEM images for samples having 1%, 3%, 5% & 10% by volume of graphite and conventionally sintered at 900°C are shown below.

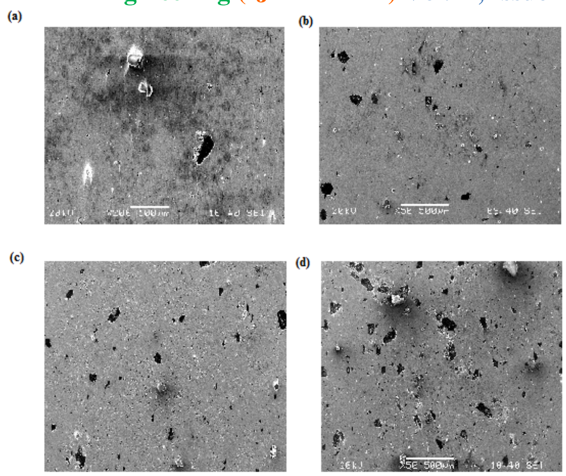


Figure 3: SEM images of conventionally sintered samples of (a) 1%, (b) 3%, (c) 5% & (d) 10% by volume of graphite

From the SEM images in Figure 3, the following observations were made: There was uniform distribution of graphite (dark regions) in the copper matrix (white regions). Also the distribution is true in the sense that at similar magnification we can see increase in number of dark regions with increase in percentage of graphite. Very less agglomeration is observed. There are few gaps observed in the copper matrix.

4. Conclusion:

Copper-graphite composite has been successfully fabricated by powder metallurgy process using conventional and spark plasma sintering techniques. XRD study shows the existence of both copper and graphite (carbon) phases along some copper oxide in conventionally sintered samples. The SPS samples were devoid of any oxide inclusions because of the vacuum conditions. SEM study suggests proper bonding between matrix and reinforcement along their interface. Hardness of Cu-graphite composite decreases with increase in amount of graphite due to soft nature of graphite. Future work Other sintering techniques like microwave sintering, hot pressing techniques, etc can be used for the fabrication of the composite.

References

1. F. F. O. Orumwense, B.A.Okorie, E. O. Okeakpu, E. N. Obiora, and L. I. Onyeji, "Sintered copper graphite powder compacts for industrial applications", Powder Metallurgy, vol. 44,(2001) 62-68

2. S. F. Moustafa, S. A. El-Badry, A. M. Sanad, B. Kieback,Friction and wear of Copper–Graphite composites made with Cucoated and uncoated graphite powders, Wear, 253,(2002) pp. 699-710.

3. M. Kestursatya , J.K. Kim , P.K. Rohatgi , "Wear performance of Copper Graphite composite and a leaded copper alloy", Materials Science and Engineering, A339, pp.(2003) 150-158

4. Rajkumar, K., Aravindan, S., Microwave sintering of copper–graphite composites, Journal of Materials Processing Technology 209 (2009) 5601–5605.