A REVIEW ON COPPER-GRAPHITE COMPOSITE MATERIAL FABRICATION & ITS MECHANICAL PROPERTIES.

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ABSTRACT

This review paper represent both fabrication & mechanical properties of copper graphite composite material. These Composites are made up of a high electrical and thermal conductivity matrix with a solid lubricant reinforcement, Making it most suitable for sliding contacts. 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. We take a Sample of copper graphite with percentage of 3%, 7%, 19%. Copper-graphite with low percentages of graphite is Used for slip rings, switches, relays, connectors, plugs and low voltage DC machines with very high current densities.

Keyword - *composite material, graphite, copper, powder metrullurgy, mmc.*

1- INTRODUCTION

Composites are exciting materials which find increasing applications in aerospace, defense, transportation, communication, power, electronics, recreation, sporting, and numerous other commercial and consumer products. Rapid advancement in the science of the fibers, matrix materials, processing interface structure, bonding and their characteristics on the final properties of the composite have taken place in the recent years. (4)

Copper is mostly used as an industrial and functional metal for thermal and electronic packaging, electrical contacts and resistance welding electrodes as it has very good electrical and thermal conductivity. However, when Cu is used as electrical contacts the mechanical properties lead to wear of the component. As graphite has very good electrical conductivity, (6) when it is reinforced into Cu, the mechanical properties improve drastically. Copper-Graphite composites are an example of metal matrix composites. (14)

Basically they are a dispersion of graphite in pure copper matrix. The composite that we will be studying about has been fabricated by powder metallurgy route (PM Route).They exhibit excellent lubricating and anti-seizing properties due to the presence of graphite and good electrical conductivity due to the pure copper. The recent recognition that addition of ceramic reinforcements enables manipulation of phys ical as well as mechanical properties of MMCs has led to increasingly widespread use of these materials in electronic packaging and thermal-management applications. Recent market forecasts suggest the prospect for accelerating growth of MMC use as the materials are more widely understood and are cheap, suggesting a bright future for this class of materials. Research and development on MMCs have increased considerably(17) in the last 10 years due to their improved modulus, strength, wear resistance, thermal resistance and fatigue resistance and improved consistency in properties and performance in general compared to the unreinforced matrix alloys.

The reinforcements are added extrinsically or formed internally by chemical reaction. The properties of MMCs depend on the properties of matrix material, reinforcements, and the matrix-reinforcement interface. Metal matrix composites (MMCs) combine both metallic properties (ductility and toughness) with ceramic properties (high strength and modulus) possess greater (13) strength in shear and compression and high service temperature capabilities. The extensive use of MMCs in aerospace, automotive industries and in structural applications has increased over past 20 years due to the availability of inexpensive reinforcements and cost effective processing routes which give rise to reproducible properties.

2-Preparation of copper-graphite composite material

2.1-Powder metrology

Powder Metallurgy may be defined as the art of producing metal powders and using them to make serviceable objects. This method has gained popularity because of the high strength, ductility and toughness that can be obtained by this route. One of the outstanding uses of powder metallurgy is the combination of hard materials in a metallic matrix, which serves as the basis of cemented-carbide products. Moreover, powder metallurgy is more economical than most other manufacturing processes.

2.1.2-Sintering

Sintering is essentially a process of bonding solid bodies by atomic forces. The sintering process is usually carried out at a temperature below the highest melting constituent. Sintering occurs by diffusion of atoms through the microstructure. This diffusion is caused by a gradient of chemical potential – atoms move from an area of higher chemical potential to an area of lower chemical potential.

Fig-1- copper material by powder metallurgy

2.1.3-Sample preparation

As received copper and graphite powders of 200gm were mixed such that the volume fractions of graphite in the mixtures 3%, 9%, 19% and respectively. Then, the samples were taken and blended together properly using a pestle and mortar for 45 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 855 MPa for 5 minutes in a die of 45 mm diameter.

2.1.4- Scanning Electron Microscope

The samples were taken for microstructural analysis using a Scanning Electron Microscope. The instrument model used was JEOL JSM-6480LV. According to requirement secondary and back scattered images were taken.

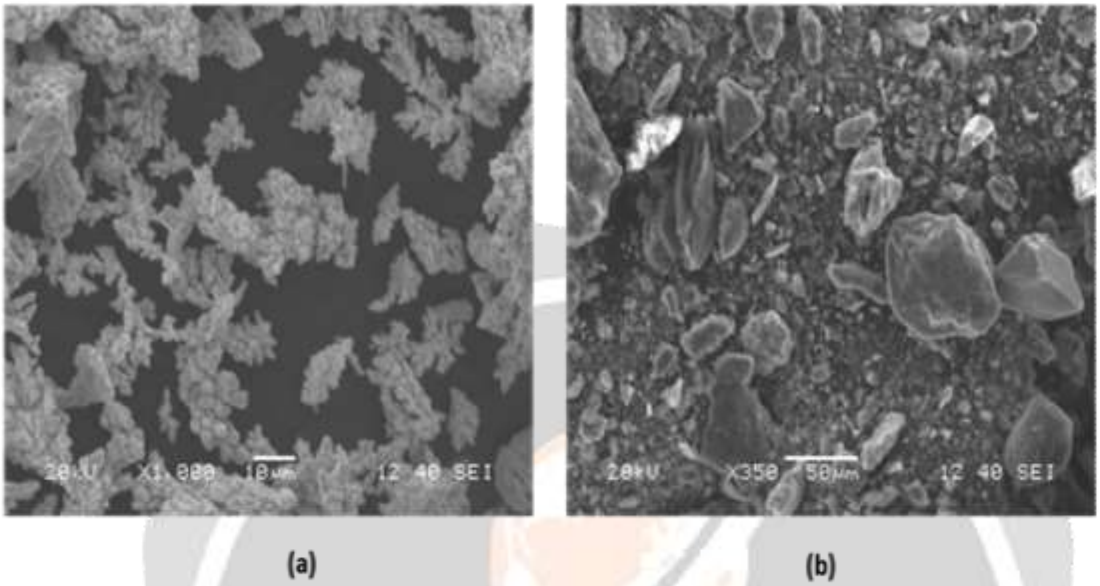

Fig.2-sem images of copper (a) & graphite (b) powder

3- LITERATURE REVIEW

K. Raj Kumar and S. Aravindan (2009) (2) studied microwave sintering of copper–graphite composites**.** Coarser microstructure with larger porosity is obtained by this conventional sintering process which decreases the strength, wear resistance as well. In microwave sintering, heat is generated internally within the material and the sample becomes the source of heat. The direct delivery of energy to the material through the molecular interaction, results in volumetric heating. Microwave sintering offers many advantages such as faster heating rate, lower sintering temperature, enhanced densification, smaller average grain size and an apparent reduction in activation energy in sintering. The finer microstructure with relatively smaller and round pores, resulted due to microwave heating, enhances the performance of the composite.

H. Yang et al. (2010) (8) studied the effect of the ratio of graphite/pitch coke on the mechanical and tribological properties of copper–carbon composites**.** Addition of pitch coke in the matrix can much improve the interfacial bonding strength between carbon particles and phenolic resin (binder). The bending strength and micro-hardness of the copper–carbon composites increased with increase in the content of pitch coke and reached a maximum. The friction coefficient of copper–carbon composites increased significantly with increasing the content of pitch coke. The wear rate of composites initially decreased as the content of pitch coke increased and obtained a minimum and then ascended.

J.F. Silvain et al. (1993) (09) studied the elastic moduli, thermal expansion and microstructure of copper matrix composite reinforced by continuous graphite fibers. Copper matrix composites reinforced by continuous graphite fibers (Cg) were processed by hot-pressing layers of metallic pre-pregs, each fiber within the yarns having previously been coated with copper by electroplating. Composites processed according to this procedure were evaluated by tensile testing and by determination of thermal expansion coefficients and chemical and structural characterizations of the graphite/copper interface. An electroplate coating followed by diffusion bonding was found to be a successful and original way to produce fully dense Cg/Cu laminated composites. Chromium can be added to improve the chemical bonding.

Wenlin MA and Jinjun Lu (2010) (10) studied the effect of surface texture on transfer layer formation and tribological behavior of copper–graphite composite**.** Metal matrix composites (MMC) containing graphite particulates usually have reduced friction under dry sliding, which is closely dependent on the formation of continuous transfer layer on the sliding surface of counterpart. Friction and wear tests were conducted under low and high load conditions and various sliding distances to evaluate the validity of the textures and their effect on the formation of the transfer layer of Cu/Gr composite.

Haijun Zhao et al. (2006) (11) investigated the wear and corrosion behavior of Cu–graphite composites prepared by electroforming. Cu–graphite composites were prepared by electroforming technique in an acidic sulfate bath with graphite particles in suspension. The interfacial bonding between metal matrix and particles is much strengthened and porosity is eliminated in the composites in case of electroforming. Corrosion takes place at grain boundaries rather than the interface between graphite particles and Copper matrix. Wear resistance is improved after the incorporation of graphite particles into copper matrix.

Simon Dorfman & David Fuksb (1996) (13) studied the stability of copper segregations on Copper/Carbon Metal-matrix Composite interfaces under alloying**.** Stability of interfaces in MMCs is linked to the conditions of the formation of segregations of the metal alloy at the metal/fiber interface. It is shown that alloying of the matrix, substituting copper in the interstitial metal-metalloid solid solution, changes the value of the mixing energy and influences the volume fraction of two dimensional segregations of copper**.** We expect that the wettability of carbon fibers by the pure copper matrix may be improved by the addition of small amounts of zirconium or iron to the matrix.

Dash, K., Ray, B.C. and Chaira, D. (2011) (14) synthesized copper–alumina metal matrix composite by conventional and spark plasma sintering and then performed characterization. The composites fabricated by SPS route do not show any peak of cuprous oxide as sintering was carried out in vacuum atmosphere. Presence of cuprous oxides was observed in the Cu/Al_2O_3 interface in the EDS of the sample fabricated by conventional sintering in hydrogen, nitrogen and argon atmosphere. The density of composites sintered by spark plasma sintering technique is quite high as compared to the other techniques. The average micro hardness value for 5% alumina reinforced $Cu–Al_2O_3$ composite is 67.8 HV for conventionally sintered samples, whereas in the present study, Nano-composites fabricated by SPS method produce an average of 124.5 HV for the same composition.

S.F. Moustafa et al. (2002) (16) studied the friction and wear of copper–graphite composites made with Cu coated and uncoated graphite powders**.** They have shown that composites made by Cu-coated and uncoated graphite have lower wear rates and friction coefficients than those made from pure copper which can be attributed to the fact that the smeared graphite layer present at the sliding surface of the wear sample acts as a solid lubricant.

Jaroslav Kovacik et al. (2007)(17) Investigated the effect of composition on the friction coefficient of copper–graphite composites in the range of 0–50 vol. % of graphite at constant load to determine critical graphite content above which the coefficient of friction of composite remains almost composition independent and constant. They investigated that up to critical concentration threshold of graphite the decrease of the coefficient of friction is governed by the synergic effect of graphite phase sliding properties and its spatial distribution within composite microstructure. Better homogeneity of graphite phase spatial distribution leads to lower coefficient of friction of composite. Then the coefficient of friction of composites becomes independent on the composition and corresponds probably to the dynamic coefficient of friction of used graphite material whereas the wear rate decreases.

Riccardo Casati and Maurizio Vedani (20) were carried out "Metal Matrix Composites Reinforced by Nanoparticles". Metal matrix composites reinforced by Nano-particles are very promising materials, suitable for a large number of applications. These composites consist of a metal matrix led with nanoparticles featuring physical and mechanical properties very different from those of the matrix. The nanoparticles can improve the base material in terms of wear resistance, damping properties and mechanical strength. Moreover, the strengthening mechanisms responsible for the improvement of mechanical properties of Nano reinforced metal matrix composites have been reviewed and the main potential applications of this new class of materials are envisaged.

H. Sun Ph.D., J. E. Orth Ph.D., H. G. Wheat Ph.D. (19) were carried out "Corrosion Behavior of Copper based Metal Matrix Composite". They investigated that the developmental composites were reinforced with graphite in either particulate or ber form. Graphite content and the presence of dissolved oxygen affected corrosion severity, and all of the developmental composites exhibited uniform corrosion and some localized galvanic corrosion at the reinforcement copper interface during polarization. Other types of corrosion damage were also observed in the noncommercial materials.

Shubham Mathur, Alok Barnawal (18) were carried out "Effect of Process Parameter of Stir Casting on Metal Matrix Composites". In the present study a modest attempt has been made to develop aluminum based silicon carbide particulate Metal Matrix Composites(MMC) with an objective to develop a conventional low cost method of producing MMCs and to obtain homogenous dispersion of ceramic material. Desired improvements in properties including specific strength, hardness and impact can be achieved by intelligently selecting the reinforcement materials, their size, and shape and volume fraction. It has been observed that melting and pouring conditions have directly or indirectly effect on mechanical properties of cast materials as hardness, percentage elongation, percentage reduction in diameter, toughness and so on.

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. Hardness of Cu-graphite composite decreases with increase in amount of graphite due to soft nature of graphite. Wear studies of the composite samples indicate decrease in wear depths with increasing volume % of graphite due to the increase in thickness of the smeared graphite layer on the surface. In general, the samples prepared by spark plasma sintering showed superior properties compared to those prepared by conventional sintering.

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