Copper Graphite Composite Material Fabrication and its Mechanical properties

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ABSTRACT

Today with the recent enlargement requirement of improvements of advanced industrial materials for several engineering applications goes on increasing. To encounter these requirements metal matrix composite is one of consistent source. Composite material is one of the best solutions for such demands. In composites, materials are collective in such a manner as to empower us to make superior use of their parental material although reducing to degree of effects of their deficits. The term 'composites' describes the mixtures of two or more material in order to advance the properties. In last years, materials expansion has moved from monolithic to composite materials for regulating to the comprehensive requirement for minimize weight, cheap in cost, increase quality, and high performance in structural materials. Copper–graphite metal matrix composites keep the properties of copper, i.e. tremendous thermal and electrical conductivities, and specifications of graphite, that means solid loosening and small thermal expansion coefficient. In this paper we present fabrication of Cu-graphite MMC by Powder metallurgy Process and we also discuss conventional and spark plasma sintering (SPS) techniques. In this work different mechanical properties like density, bulk hardness and wear study are also analysed.

Keywords: *Composite Material; Graphite; Copper; Powder Metallurgy; MMC.*

I. Introduction

The term 'composites' describes the mixtures of two or more material in order to advance the properties. In last years, materials expansion has moved from monolithic to composite materials for regulating to the comprehensive requirement for minimize weight, cheap in cost, increase quality, and high performance in structural materials. Driving force for the use of AMCs in areas of region and automotive industries embody performance, economic and environmental advantages. Copper has been used for many years and its mechanical specifications area unit standard. Its utilization in several divisions of business is exhaustive and has been steady growing in recent years. The key area unit in electric, industrialised equipment, copper-based alternative energy collectors, and integrated circuits and usually in physical science.

Copper is conjointly used terribly efficiently careful readings of a bonding of mechanical specifications and microstructure are performed within the previous century. The fundamental information is found in related article, (by Murphy, 1981) atomic number 29 may be an easy f.c.c. material This can be why it's been often used as a typical material for elementary work of damage procedures in metals, notably weakness and slink. It goes from this time of read to the foremost totally examined materials. The analysis was accompanied each on poly-crystals and particular crystals. the good pact of the set of basic data on fatigue damage procedure, variations of displacement edifices, allocation of repeated physical property, beginning and transmission of fatigue cracks was non inheritable simply on this typical material.

Fibers and particles mixed uniformly in matrix of another material are the best sample of modern-day composite materials. In matrix-based structural composites, the matrix aids two relevant drives i.e. binding the reinforcement stages in place and allocating the stresses among the essential reinforcement materials under an applied force distributes the stresses among the constituent reinforcement materials under an applied force. The ordering is generally made with respect to the matrix type. The major composite classes comprise Organic Matrix Composites (OMCs), Metal Matrix Composites (MMCs) and Ceramic Matrix Composites (CMCs). The word organic matrix composite is usually presumed to contain two classes of composites, namely Polymer Matrix Composites (PMCs) and carbon matrix composites generally referred to as carbon composites.

Metal Matrix composites (MMCs) are the kind of materials which employs particles as reinforcement and ductile metal or alloy is taken as a matrix. The accumulation of reinforcement in the metal matrix improves strength, stiffness and various other properties as compared to the conventional metal. Copper is one of the most popular matrix material due to its good thermal conductivity, electrical conductivity and corrosion resistance. Metal matrix composites are generating a wide interest in research field nowadays.

II. MMC

Advanced composites based on metallic matrices have a somewhat recent history, yet the opportunities look very promising. The first MMCs were developed in the 1970s for high-performance applications using continuous fibers and whiskers for reinforcement **[1].** The wide usage of MMCs in aerospace, motorised engineering and in organisational applications has improved over past 20 years because of the obtainability of economical reinforcements and nominal cost processing routes which give growth to reproducible benefits **[2]**. At the time of project of a MMC the fundamental interfacial singularity which rules the conduction of thermal, electrical and transmission of mechanical properties is of chief importance **[3].**

Research and development on MMCs have increased considerably 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 un-reinforced 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 **[4].**

III. Related Work

K. Rajkumar and S. Aravindan [5] proposed a framework for microwave sintering of copper–graphite composites. In microwave sintering, heat is generated internally inside the fabric and therefore the sample becomes the supply of warmth. The direct delivery of energy to the fabric through the molecular interaction, ends up in volumetrically heating. Microwave sintering offers several benefits equivalent to quicker heating degree, lesser sintering hotness, increased compression, lesser average scrap dimension and a plain decrease in energy in sintering. The finer microstructure with comparatively slighter and spherical apertures, resulted thanks to microwave central heating, enhances the enactment of the combination. H. Yang et al. [6] described the impact of the relation of graphite/pitch coke on the mechanical and tribological things of copper–carbon compounds.

J.F. Silvain et al. [7] focused the elastic moduli, thermal expansion and microstructure of copper-matrix composite strengthened by incessant graphite fibers. Compounds processed in line with this process were estimated by tensile analysis and by finding of thermal growth factors and organic and structural depictions of the graphite/copper interface. Associate in electroplate coat trailed by dispersion bonding was initiate to be a undefeated and original thanks to turn out absolutely dense Cg/Cu laminated composites atomic number 24 is more to enhance the chemical bonding. The outcome of surface texture on transmission layer founding and tribological behaviour of copper–graphite composite is discussed by W. Maa et al. [8]. H. Zhao et al. [9] examined the wear and corrosion behaviour of Cu–graphite composites organised by electroforming. The constancy of copper segregations on Copper/Carbon Metal-matrix Composite interfaces under alloying proposed by S. Dorfman et al. [10].

IV. Procedure

Powder metallurgical procedures have numerous benefits of using over other methods like as the probability of finding uniform brushes and of sinking the dull and expensive machining procedures. Through contrast, there are some confines of this terminology connected with the deprived similarity among copper and graphite, which provides increase to weedy interfaces with the resulting bad impact on the organisational, electrical and mechanical specifications of the manufactured article.

A great wear resistance of this measureable is compulsory due to the brushes scrub on revolving metal parts. To enhance the wear resistance it is essential to retain absorbency dejected to a least. Energies to yield solid brush resources with tin and lead and with maximum power transmission and raised working temperature ensued in an alliance route, which employed concurrent pulse heating system and powder compaction. Moustafa et al. [14] have described that copper–graphite composites made from a combination of copper and copper-layered graphite dusts influenced an advanced sintered compactness and produce strength than those formed from a combination of copper and un-layered graphite powders. Tribological specifications of the mixtures be subject to on the organisation of the matrix and the circulation of the graphite in the matrix. The adding of minor quantities of lead and zinc to the compound rises the rigidity and toughness.

Commercial copper powder of 50μm and graphite of 35 μm is used in experiment. For evenly mixing process rotating drum mixture has been used and cold compaction process was performed to get required shape under different applied pressure. .After compacting the resultant the green compacts were sintered at a temperature under the change point of the copper residue used. Nine samples were organized using the taguchi L9 array method where the configuration is varied to decrease the mass of the total metallic matrix composite. For every compound three various samples were prepared with three different pressure level and at temperature and various sintering times. For samples in order Gr-2%, 5%, 10%.

For calculation of volume, width and length of all the samples were measured by with Vernier caliper. The quantity of all the samplings were measured by the ordinal balancing device and calculation of density is done by given Eq. 1.

$$\boldsymbol{Density} = \frac{\boldsymbol{Mass}}{\boldsymbol{Volume}} \qquad \textbf{Eq. 1}$$

For measurement of hardness a Vickers hardness test equipment was used and the hardness was measured to be 100 kgf load by using diamond indenter tool of HV scale. For observation of microstructure all the nine samples were refined with emery paper of following scores 220,400,600,800, 1000. Microstructure of every samples was deliberated in account of electrical optical microscope and duplicate were captured.

For the power transmission, Resistance (R) was measured with the assistance of multi-meter of all nine samples and then calculation of electric resistivity (ρ) is given by Eq.2.

$$\boldsymbol{\rho} = \frac{\boldsymbol{R \times A}}{\boldsymbol{L}} \qquad \textbf{Eq. 2}$$

Where, L= length of case
A= Area of cross-section

The electrical conductivity given by (σ) Eq. 3.

$$\sigma = \boldsymbol{1/\rho} \qquad \textbf{Eq. 3}$$

V. Result Analysis

Nine sample of the composite are represented in table 1.

S. No.	Composition	Pressure	Temperature	Time
1	Cu98%-2% Graphite	400 MPa	650 ^{0}C	1 hr
2	Cu98%-2% Graphite	500 MPa	700 ^{0}C	2 hrs
3	Cu98%-2% Graphite	600 MPa	750 ^{0}C	3 hrs
4	Cu95%-5% Graphite	400 MPa	650 ^{0}C	1 hr
5	Cu95%-5% Graphite	500 MPa	700 ^{0}C	2 hrs
6	Cu95%-5% Graphite	600 MPa	750 ^{0}C	3 hrs
7	Cu90%-10% Graphite	400 MPa	650 ^{0}C	1 hr
8	Cu90%-10% Graphite	500 MPa	700 ^{0}C	2 hrs
9	Cu90%-10% Graphite	600 MPa	750 ^{0}C	3 hrs

Table.1 Different sample of Composite Material

A. Density

By the observation it is found out that as we increase wt.% of graphite elements in the copper matrix the density reductions. It has a minimum compactness at Cu-10% graphite and maximum density at Cu-2% graphite. This is because as the wt% of graphite increase and simultaneous decrement in the wt.% of copper amount ultimately drop down the density as the compactness of graphite is 2.25 gm./cc which is lesser than that of copper which is around 8.8 gm./cc. Pressure does have a part in the modification in compactness from the graph studies. . At 500MPa pressure the density is optimum.

From the Fig.1 it is observed that density decreases as the temperature of the sintering process increases as it reduces porosity from the MMC. It is lowest at 700˚C and maximum at 650˚C.

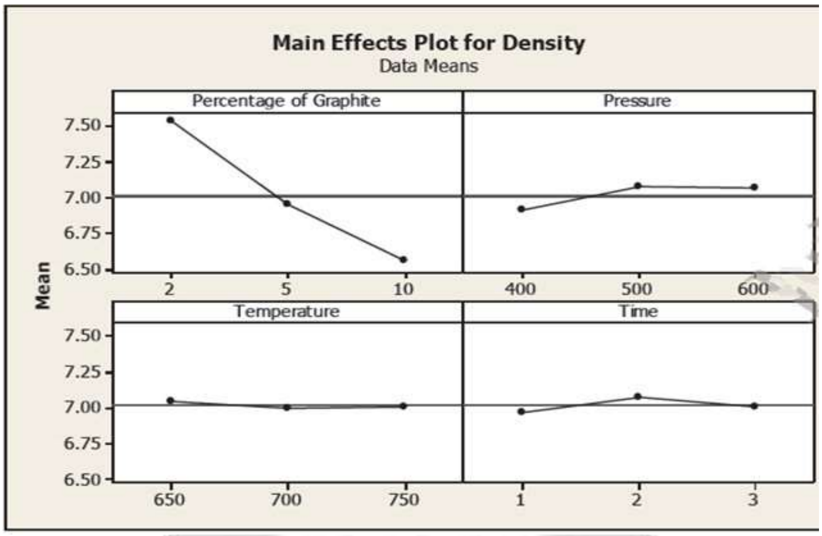

Fig.1 Density vs. Percentage of Graphite, Pressure, Temperature, Time

B. Electric Conductivity

From the Fig.2 it is observed that as we increase the wt% of graphite the electrical conductivity increases up to Cu- 5% graphite and start decreases further as graphite wt% is increased resistance between material increase because of bad affinity of material towards each other and clustering effect. Electrical conductivity is almost constant as we increase pressure of compacting.Fig.2 It has a minimum value at 600MPa and maximum value at 400MPa pressure.

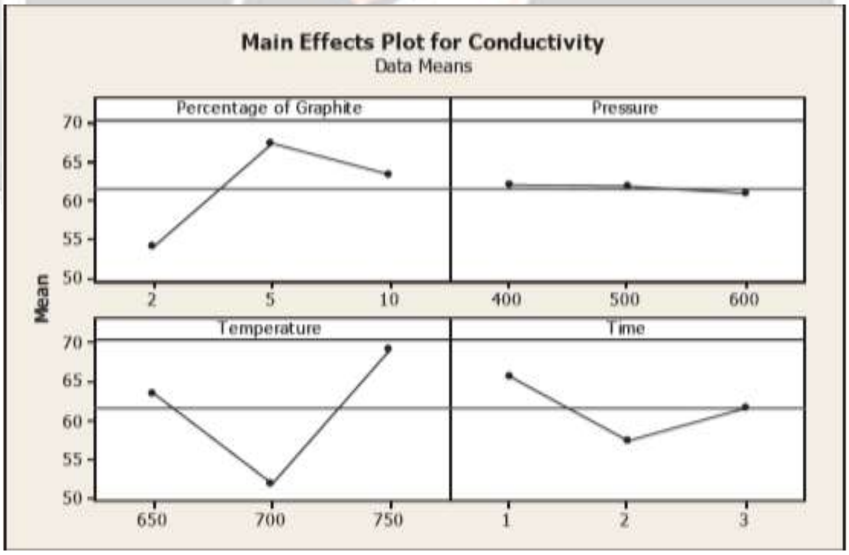

Fig.2 Electrical Conductivity vs. Percentage of Graphite, Pressure, Temperature, Time

C. Hardness

From the Fig.3 it is observed that as wt% of graphite in the copper matrix increases the hardness of the compound decreases. . This is because of Gr has fewer hardness than Cu. The particle of graphite does not offer sufficient hardness to overawe the blow transmission in the Cu matrix and reduces the hardness.

From Fig.3 it is observed that as sintering temperature increase the value of hardness decrease displays that the supreme hardness is perceived at 650˚C and least at 750˚C.

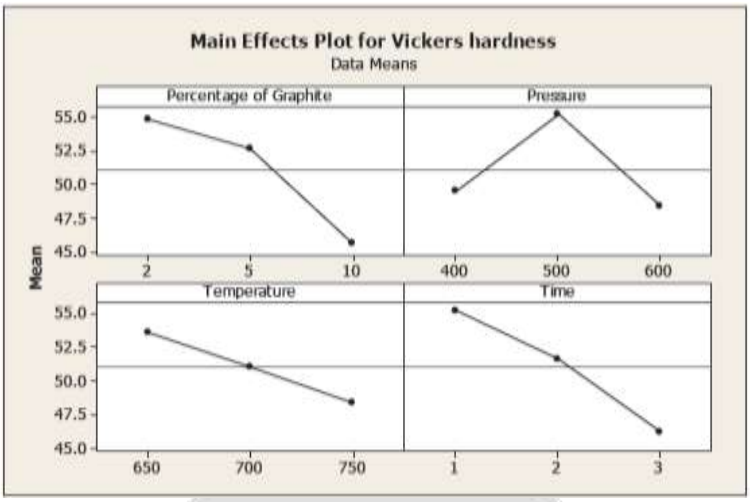

Fig.3 Hardness vs. Percentage of Graphite, Pressure, Temperature, Time

VI. Conclusion

In this paper, we generate Cu-Gr metal matrix composite by powder metallurgy route and analyse the fabrication of Cu-graphite MMC by Powder metallurgy Process and different mechanical properties like density and hardness are also analysed. And we examined that density decreases as wt% of graphite increases and Electrical conductivity decreases as wt% of graphite increases. Conductivity remains almost the same with increase in the pressure.

VII. References

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