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PARAMETRIC ANALYSIS FOR THE DEVELOPMENT OF COPPER SILICON CARBIDE METAL MATRIX COMPOSITES USING STIR CASTING

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ABSTRACT
Smart materials are in picture due to the requirement of light weight and high strength material having good mechanical properties for different application. Copper material composite acquire all the requirement properties for the applications. Copper Silicon Carbide composite material made using stir casting investigation is carried out to check different properties of Cu-SiC Particulate Reinforced Metal Matrix Composites. Also machining parameters are checked for the application of PRMMC in industry. Copper (Cu) has a better thermal conductivity than aluminum (Al), therefore, copper should be the best candidate as thermal material. With the presence of silicon carbide (SiC) as reinforcement, copper silicon carbide should be able to perform better as a heat spreader or a heat sink than aluminum silicon carbide (AlSiC) metal matrix composite.

Keywords: *Copper (Cu), Silicon Carbide (SiC), Stir Casting, Composites.*

I. INTRODUCTION

With the modern development developments of advanced engineering materials for various engineering applications goes on increasing. To meet such demands metal matrix composite is one of reliable and good source. Composite material is one of the best solutions for such requirement [1]. In composites, materials are combined in such a way as to enable us to make better use of their parent material while minimizing to some extent the effects of their deficiencies. The simple term 'composites' gives indication of the combinations of two or more material in order to improve the properties. In the past few years, materials development has shifted from monolithic to composite materials for adjusting to the global need for reduced weight, low cost, quality, and high performance in structural materials [2]. Driving force for the utilization of AMCs in areas of aerospace and automotive industries include performance, economic and environmental benefits. Cu cannot use because of its low strength. Therefore improvement in the properties of copper has become essential for its applications in cutting – edge technological applications. Copper at the nano-scale becomes more useful due to the fact that copper nano- particles have high surface area and small size [3]. The improvement of the mechanical properties of copper is important for its use in a large number of fields. Composites material offers several applications in aerospace, automotive and ship building industries as they have certain advantage over other convention metals. Metal matrix composites (MMCs) combine both metallic properties such as toughness and ductility and ceramic properties such as elastic modulus and high strength, which endow shear strength providing service at high temperature. Copper has high thermal conductivity and use as a structural material for cooling. In order to increase its high temperature properties, different reinforcements are being used [4][2].

II. METHOD & MATERIAL

Matrix material
In the present study copper is used as a matrix material for checking the impact of the reinforced material on it some of the properties of the copper is given below in the table.

Table 1 Properties of Copper

Properties	Value
Melting point	1084 °C
Density	8.96 g/cm^3
Thermal expansion	16.5µm/(m*k)(25)
Thermal conductivity	401 w/(m k)
Electrical resistivity	16.78 nΩ m (at 20 °C)

Reinforcement material

Silicon is the only chemical compound of carbon and silicon. It was originally produced by a high temperature electro-chemical reaction of sand and carbon. Silicon carbide is an excellent abrasive and has been produced and embedded into grinding wheels and other abrasive products for over one hundred years. Today the material has been developed into a high quality technical grade ceramic with very good mechanical properties. It is used in abrasives, refractory, ceramics and numerous high-performance applications. The material can also be made an electrical conductor and has applications in resistance heating, flame igniters and electronic components [5]. Silicon carbide is composed of tetrahedral of carbon and silicon atoms with strong bonds in the crystal lattice. This produces very hard and strong material. The high thermal conductivity coupled with low thermal expansion and high strength gives this material exceptional thermal shock resistant qualities. Silicon carbide ceramics with little or no grain boundary impurities maintain their strength to very high temperatures, approaching 1600 degree Celcius with no strength loss.

The following are main advantages of using Silicon carbide as reinforcement:

- Low density
- High strength
- Low thermal expansion
- High thermal conductivity
- High hardness
- High elastic modulus
- Excellent thermal shock resistance
- Superior chemical inertness

Table 2 Properties of Silicon Carbide

Properties	Value
Melting point	2200-2700 ˚C
Density	3.2 g/cm3
Thermal expansion	4.5µm/(m*k)(25)
Fracture toughness (MPa-m1/2)	4.6
Electrical resistivity	16.78 nΩ m (at 200 °C)

Manufacturing methods

Stir casting is the one of the exhaustively used and economical synthesis technique for fabricating the particulate reinforced composite. It is simpler as compared to other available techniques and flexibility in tailoring the desired properties in the composite.

In stir casting the material is placed in a graphite crucible and melted in a pit furnace. When the melt is in liquid state, the stirrer mechanism is introduced into the melt. The stirrer mechanism is rotated at specified rotation to create a vortex in the melt. The reinforcement particles are introduced in to the melt through the side of the vortex formed. The vortex sucks the particle and distributes it in to the melt. The vortex method is one of the better known approaches used to create and maintain a good distribution of the reinforcement material in the matrix alloy. Stirring for sometime followed by mixing is done to obtain homogeneous distribution of particles. The next step is the solidification of the melt containing suspended particles under selected conditions to obtain the desired distribution of the dispersed phase in the cast matrix.

Fig 1: Developed Setup of Powered stir casting

III. EXPERIMENTATION

Before finalizing a particular orthogonal array for the purpose of designing the experiments, the following parameters must be established:

Table 3 Parameters used for Manufacturing of casting

Melting temperature	1084°C
Total Stirring time	3 minutes
Stirring speed	450 rpm
Blade angle	90°
No. of blades	4
Position of stirrer	up to 1/2 depth
Plate size	100*100*10 mm

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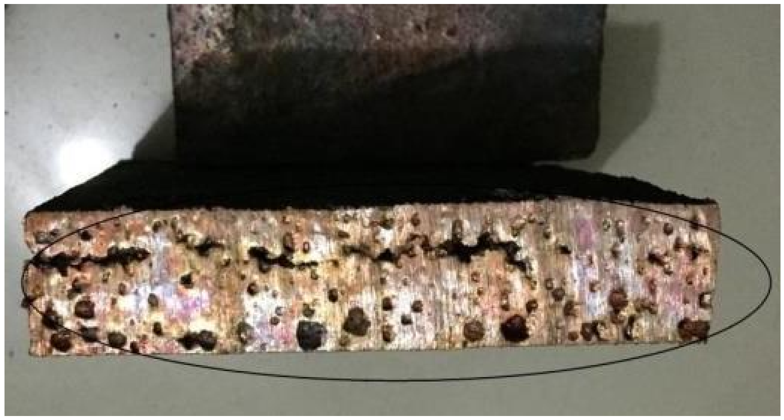

Fig 2 Defects in CuSiC casting

Defects are identified in the prepared material because of the following probable reasons:

1. Heterogeneous SiC Distribution in Cu Material
2. Less Stirring Speed
3. Less Stirring time
4. Improper Solidification
5. Manual casting error

In the parameters of the casting, some following changes have been applied to get the proper casting.

Table 4 Changes in Parameters used for Manufacturing of casting plates

Melting temperature	1084˚C
Total Stirring time	6 minutes
Stirring speed	550 rpm
Blade angle	7˚ Helix angle
No. of blades	4
Position of stirrer	up to 2/3 depth
Plate size	100*100*10 mm

After applying the changes, following material has been obtained.

Fig 3 Plate after applying changes in parameters

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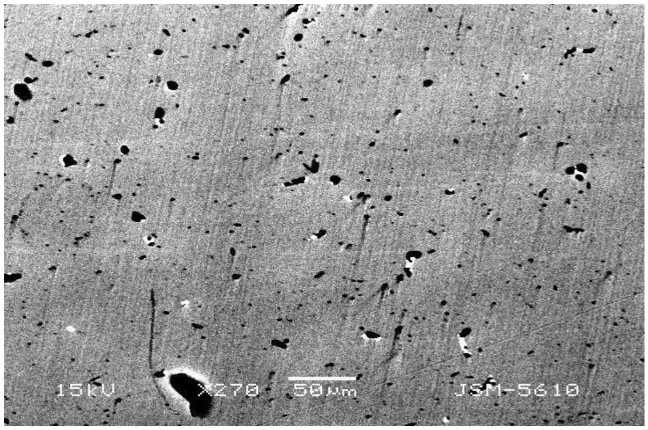

Figure 4 Micrograph of sample containing 10% SiC by weight

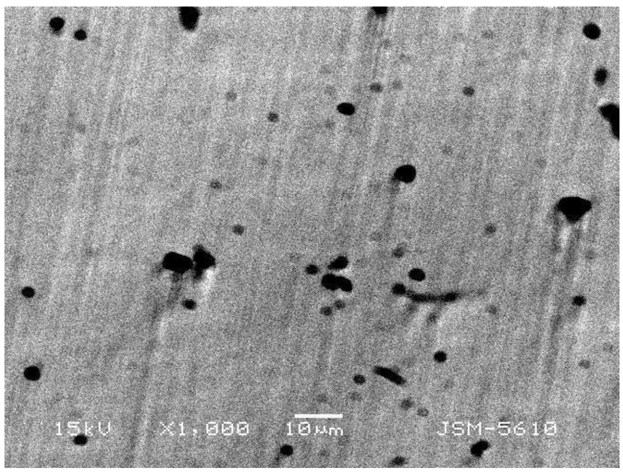

Figure 5 Micrograph of sample containing 7% SiC by weight

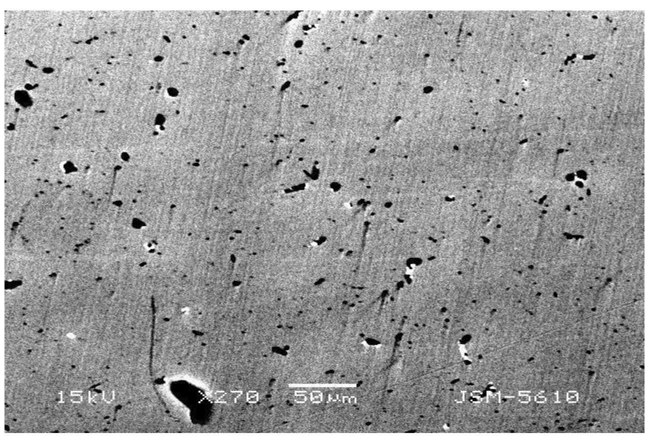

Figure 6 Micrograph of sample containing 5% SiC by weight

IV. RESULTS

Results from the Scanning Electron Microscope (SEM) and visual inspection shows that homogeneous metal matrix composite can be obtained by properly varying the process parameters.

V. CONCLUSION

- Optimum stirring speed for homogenous casting of CuSiC is 550 rpm because below that stirring speed porosity is shown in the casting of this composite.
- Perfect stirring time for the casting of CuSiC composite is 5-6 minute for homogenous casting is preferable from the manufacturing of CuSiC composite.
- SEM results show the homogenous distribution of SiC particle in the Cu metal matrix composite.

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