Development of Ex-situ Al/B_4C MMC by Stir Casting Technique

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Abstract— **Aluminium Metal Matrix Composites are increasingly finding an important role in low strength to weight ratio at low cost (compared to titanium alloys) coupled with good corrosion resistance. These alloys have been widely used in aeronautical components, automotive parts, instrumentation cases and electric motors. Aluminium alloys are commonly used due to very attractive characteristics such as high strength to weight ratio, good thermal conductivity, good formability, corrosion resistance and excellent cast facility and are widely used in wear applications like brakes, pistons, cylinder liners and motor casing. By improving the wear characteristics of these alloys, the functionality of these alloys can be broadened and used in many more applications.**

Keywords

I. INTRODUCTION

Aluminium based metal matrix are known for very promising light materials enhanced mechanical properties. Aluminium based metal matrix composites have considerable applications in aerospace, automotive, military industries due to their high strength to wear ratio, stiffness, concurrent wear resistance, high hardness, stability at high elevated temperature, corrosion resistance and improved thermal properties. [1-4] Aluminium boron carbide metal matrix composite combines the desirable attributes of aluminium and boron carbide. It is known that combining B_4C with a metal can mitigate the problems associated with brittleness. Aluminium wets B_4C well at elevated temperatures. [8]

Aluminium metal matrix may be laminated fibers or particulate composites. These materials are usually processed through powder metallurgy route, liquid cast metal technology or by using a special manufacturing process. Powder metallurgy process has its own limitations such as processing cost and size of the components. [10] Therefore, only the casting method is to be considered as the optimum and economical route for processing of Al composite materials. Stir casting is appealing for its flexibility in selecting raw materials and processing conditions through which composites with matrixes and reinforcing phases having been successfully fabricated. However, major challenges lie in wetting, and chemical reactions between the ceramic particles and the matrix, homogeneous distribution of reinforcement materials, the fluidity of the composites and porosity in the cast metal matrix composites and wide adoption of stir casting method depend satisfactory resolution of these technical difficulties. [9]

In stir casting, we use stirrer to agitate the molten metal matrix. The stirrer is generally made up of a material which can withstand at a higher melting temperature than the matrix temperature. The stirrer is consistingof mainly two components cylindrical rod and impeller. The one end of the rodis connected to the impeller, and another end is connected to the shaft of the motor. The stirrer isgenerallyheldin a vertical position and is rotated by a motor at various speeds. The resultant molten metal is then poured in die for casting [11].

II. EXPERIMENTAL PROCEDURE

A. Material

For the fabrication of Al mmc's, the AA 2000(shown in Fig 1a) is used as a matrix material. Boron Carbide (B4C) particles were used as ex-situ reinforcements; whereas scrap magnesium is added as a wetting reagent in between particles and matrix. The chemical composition of initial pure Al alloy taken for the synthesis of different composites is shown in Table 1 as per the analysis carried out in emission spectroscopy. The particle size of B_4C particle (shown in Fig 1b) is 300 mesh sizes.

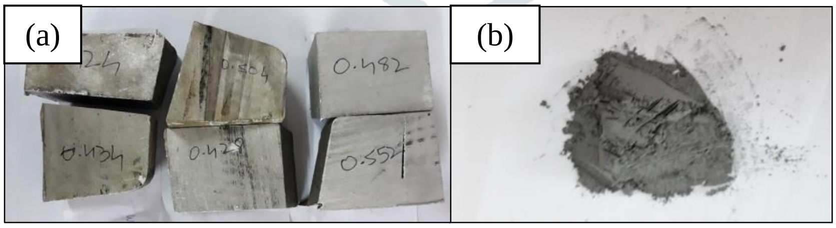

Fig:1 (a) Procured aluminium (b) B_4C powder

TABLE 1. The chemical composition of procured AA2000.

Element	Cu	Mg	Si	Fe	Zn	Mn	Ni	Sn	Al
Wt%	1.5~3.5	0.30	9.6~12	0.90	1	0.50	0.50	0.20	Bal

B. Die Design

To pour molten metal we use different dies. We are using metal die because of its wide advantages. Metal dies can sustain at high temperature as well as it gives definite shape of the mould. Mild steel has been used as a metal die material. By the reverse calculations of volume we had defined the size of die as 150 mm length, 50 mm width, 50 mm height (shown in Fig 2).

Fig:2 Metal die

C. Stirrer design

Solid model of stirrer(shown in Fig 3) assembly with length of 650 mm, width 100 mm, blade thickness 2 mm, stirrer rod diameter 16 mm. these partsare made from mild steel which can sustain high temperature more than 1000 ºC. This stirrer assembly covers by glass wool for protection to motor. This stirrer assembly is used for mixing purpose of molten metal (Al) and nanoparticles (B_4C). Nanoparticlepreheateris used for heating the nanoparticles at different temperature and nanoparticles push rod is used to push the heated nanoparticles into liquid metal with a uniform flow of nano solid particles. While designing stirrer some parameters were tested as Temperature and total heat flux. These parameters were tested in ANSYS (16.0). From this analysis, it was understood that stirrer is sustainable to this temperature.

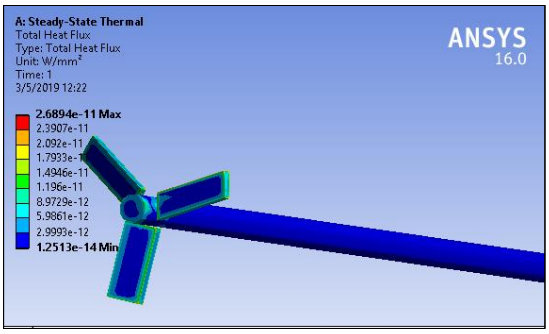

Fig: 3 Thermal analysis of stirrer

D. Fabrication of Al-B_4C Composite

AA 2000 was used as it had a lot more advantages. B4C with an average particle size of 50 µm were selected as the reinforcements. Al/B4C composites with reinforcement of 5 wt. %, 10 wt. % and 15 wt. % of B4C powders were fabricated by using stir casting process. [6] In a stir casting process, usually the particulate reinforcement is distributed into the aluminium melt by mechanical stirring. In 1968, S. Ray incorporated alumina particles into the aluminum melt by stirring molten aluminium alloys containing the ceramic particles[7].By stir casting technique, the aluminium metal matrix is melted in a graphite crucible heated to 900 ºC about 1 kg. When the temperature of the melt is about 50 ºC above the pouring temperature, the preheated stirrer is introduced in the melt. Agitation of the melt is started and the preheated B_4C of 5 wt.% are added as reinforcements. Aluminium requires a temperature as high as 1100 ºC for wetting the B_4C surface completely. At such high temperature, the processing leads to the formation of undesirable compounds such as Al3BC, AlB2 and Al4C3 due to the chemical reactions between Al and B4C. For improving the wettability of B4C with aluminium alloy at below 850ºC, hexachloroethane (C_2Cl_6) is added. The mechanical stirrer is used to form the vortex. The stirrer speed was kept constant at 300-400 rpm approximately and it was continued 10 min. The mechanical stirring distributes the particle in the melts, and it gives uniform distribution of the reinforcements. [6] The major advantage of the stir casting process is its applicability to mass production. Compared to other fabrication methods, stir casting process costs as low as 1/3rd to 1/10th for mass production of metal matrix composites [7]. The stir casting set up shown in Fig 4a. After mixing the reinforcement particle in the Al melt pour the melt in the metal casting die(shown in Fig.4b).After pouring liquid metal left for solidified and the developed specimen shown in Fig.4c.

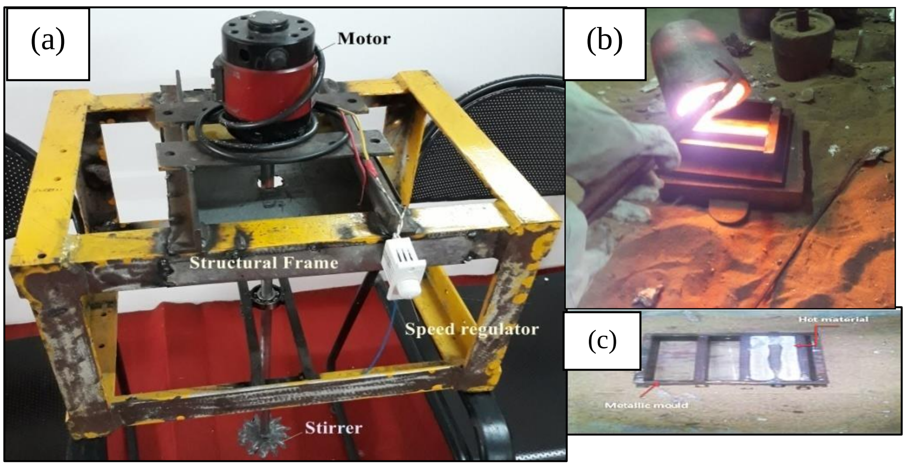

Fig: 4 (a) Stir casting setup (b) Pouring of liquid metal (c) developed Al-MMC

III. Conclusion

We have successfully developed metal matrix composite with different processing variables such as holding temperature, stirring speed, the design of the impeller, and the position of the impeller in the melt are among the important factors to be considered in the production of cast metal matrix composites as these have an impact on tribological properties. These are determined by the reinforcement content, its distribution, the level of the intimate contact of the wetting with the matrix materials, and also the porosity content. Therefore, by controlling the processing conditions as well as the relative amount of the reinforcement material, it is possible to obtain a composite with a broad range of mechanical properties as well as tribological properties. The adopted method is potentially very cost-effective and can be widely used in others composite development.

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