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Synthesis and Characterization of AA6063-3 wt. % TiC Composites

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Abstract-The present work aims to synthesize AA6063-3 wt. % TiC composite through stir casting route and to analysis the microstructure. These combinations are expected to be used in transportation, construction and similar engineering industries. The addition of 3 wt. % of TiC as the particulate in the properties of AA6063, the microstructure can be greatly changed. A detail study of the structure of the composites was carried out.

Index words - Al-TiC composite, stir casting, SEM.

I. INTRODUCTION

Composite refers to a material system which is composed of a reinforcement distributed in a matrix and which derives its distinguishing characteristics from the properties of its reinforcement, from the geometry and architecture of the reinforcement as well as from the properties of the interfaces between different reinforcement [1]. Metal matrix composites (MMCs) have many advantages over monolithic metals including higher specific modules, higher specific strength, better properties at elevated temperatures, and lower coefficient of thermal expansion, in addition to better wear resistance. Aluminium is favored as matrix materials in MMCs because of its low density, easy fabricability and good engineering properties. Aluminium MMCs can be reinforced with various oxides, carbides, nitrides and borides in particulate such as SiC, Al2O3, B4C, TiC, MgO, TiO2, AlN, BN and Si3N4[2-6]. Where as in reinforcement TiC particles projected significance due its predominant wettability and strong interfacial bonding with matrix in fabrication of composite materials. The practical applications of Al-TiC metal matrix composites are in aerospace, automobile and structural industries [7]. The synthesized Al-10TiC in situ composite by the reaction of molten Al with K2TiF6 and graphite powder at 12000C. In stir casting process the presence of TiC, and the TiC particles were segregated towards the grain boundary. TiC particles can be synthesized in situ by several ways such as salt reaction with the molten Al, addition of Al-Ti-C powder compact or by the reaction of CH4 gas with the melt [8]. The developed Al-5Ti-0.8C and Al-5Ti-1.2C master alloys with TiC particles for the grain refinement of Al- 7Si alloy [9]. The Al-TiB2 composites by the addition of Al-Ti-B powder preform to the molten Al at 9000C and studied the mechanism of formation of TiB2 [10]. The commonly used reinforcement is silicon carbide particulates in cast alloy matrix and alumina particulates in wrought alloy matrix [11]. The mechanical properties of the composites, as fabricated and heat treated, showed a strong dependency on the ceramic content [12]. After heat treatment, the 55% TiC composites showed an increase of hardness from 28.5 to 38.5 HRC; meanwhile ultimate tensile strength increased from 379 to 480 MPa. Al-TiC composites are processed at different temperatures from 700°C to 1200°C and with different Ti: C ratios to asses the effect of these two parameters on the formation of TiC particles [13]. Microstructural features and X-ray diffraction results show that at temperatures below 1000 °C blocky type Al3Ti forms. The temperature is increased the blocky nature of Al3Ti changes to needle like indicating release of Ti to a greater extent and as a result more and more TiC particles form. Al-TiC composites were produced by a casting route assisted by self-propagating high-temperature synthesis [14]. Fluxes were used to activate in reaction in the aluminum melt and promote higher Ti and C yield in the composites. The TiC stoichiometry corresponded to C/Ti ratios from 1.0 to 0.8. The in situ synthesized TiC particles possess a metastable FCC crystal structure with an atomic composition of TiC08 and a lattice parameter of 0.431nm [15]. The typical ingot metallurgy microstructures exhibit aggregates of TiC particle phase segregated generally at the Al sub grain or grain boundaries and consisted of fine particles of 0.2-1.0nm. After re-melting of the ingots and hence rapid solidification, the microstructures formed under certain thermal history conditions contained uniform fine-scale dispersion of TiC phase particles an aluminum supersaturated matrix.

	AA6063	TiC
Density (kg/m^3)	2700	4935
Melting point (°C)	650	3075
Yield Strength(MPa)	48	114
Thermal Conductivity (W/mK)	200	32

II. EXPERIMENTAL WORK

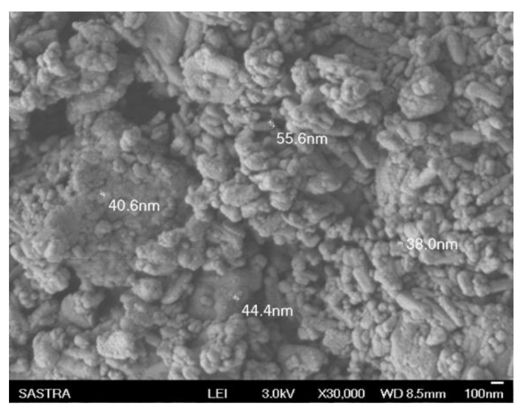
A typical chemical composition and properties of AA6063 is presented in Table 1 and 2 respectively. The SEM image of TiC powder is shown in figure 1 and the size of the particles is noted in the image and properties are presented in table 2.The reinforcement based on TiC particulate is attractive for the aluminum matrix because of its good wettabilityby aluminum, which can result in a clean and strong interface [15]. The Al: TiC composite at a temperature close to the melting point of aluminum, the strength and modulus can be increased substantially along with a corresponding decrease in ductility. The quantity of AA6063 and TiC particles required to produce composites having 3 wt. % of TiC. AA6063 was melted in a crucible by heating it in a furnace at 750°C for three to four hours. The experimental setup of manufacturing AA6063-3 wt. % TiC composite is shown in figure 2. The TiC particles were preheated at 1000ºC to make their surfaces oxidized. The furnace temperature was first raised above the liquidus temperature of Aluminum near about 750ºC to melt the AA6063 completely and was then cooled down just below the liquidus to keep the slurry in semi solid state. The preheated TiC was added at this temperature and stirring of slurry was performed manually for 3-5 minutes. The composite slurry was then super heated to 720oC and a second stirring performed by mechanical stirrer to improve the distribution of the TiC particles in the molten of AA6063. The molten composite was then cast into prepared steel molds. The presence of reinforcement throughout the specimen was inspected by cutting the casting at different locations and under microscopic examination [8].

Table1. Chemical composition of the AA 6063

AA6063	Si	Mg	Fe	Cu	Mn	Al
Weight (%)	0.44	0.56	0.46	0.02	0.03	Bal.

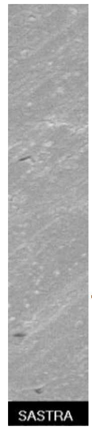
Table 2. Properties of AA6063 and TiC powder

III. RESULTS AND DISCUSSION



Figures 3-5 show the microstructures of as cast AA6063-3 wt. % TiC composite. The reinforcement particles have shown little clusters forming fairly uniform particle distribution in composite containing 3 wt. % TiC.

Fig.1 SEM micrograph of TiC powder.



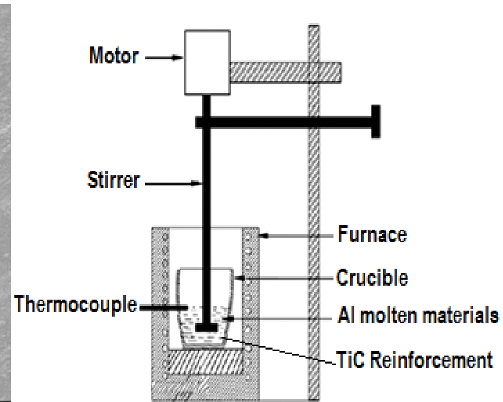


Fig. 2 Experimental setup of stir casting process [9].

However, at lower magnifications of optical microscope (Figure 3a & b), the samples seem to have a more uniform distribution of the TiC reinforcement. But with an increase in the magnification, the presence of particle agglomerations is clearly visible as in Figure 4a & b. Another observation in Figure 5a & b images is the breakdown of TiC aggregates into smaller individual particles. The shear force applied on the composite mixture by the impeller is the main reason to break down most of the TiC aggregates and overcome its cohesive force. The rotation of the stirrer generates a vortex through which the TiC particles are drawn into the melt. Moreover, the rotation of stirrer can create high and local shear forces that are exerted on the clusters helping to break down TiC cluster particles. Under a high shear and high intensity of turbulence, liquid metal can penetrate into the clusters of the particles and displace the individual particles apart. During the stirring and mixing process, the air bubbles are sucked into the melt via the vortex created. The TiC particles tend to become attached to these air bubbles would envelope the reinforced particles, leading to the formation of particle porosity clusters. The interfaces between TiC and the AA6063 matrix are atomically abrupt, and no impurities were detected.

It is suggested that the interfacial characteristics depend on the size of the particles and on their orientation with respect to neighboring Aluminum grains. Figures 5 can be seen that TiC reinforcement particles were broken to smaller particulates. Most of the particulates may not appear in the figure because their sizes are less. It shows the micrograph of as cast AA6063-3 wt. %TiC, the light gray areas indicate the TiC particles that are embedded in the AA6063. The starting coarse TiC particles are broken down to lesser size and their distributions are more uniform compared to as cast structure shown in Figure 4. It achieved a homogeneous distribution of TiC in the AA6063, as it is one of the problems associated with the production of cast MMCs.

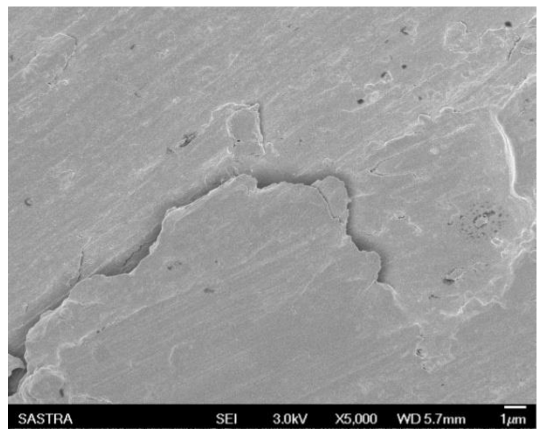
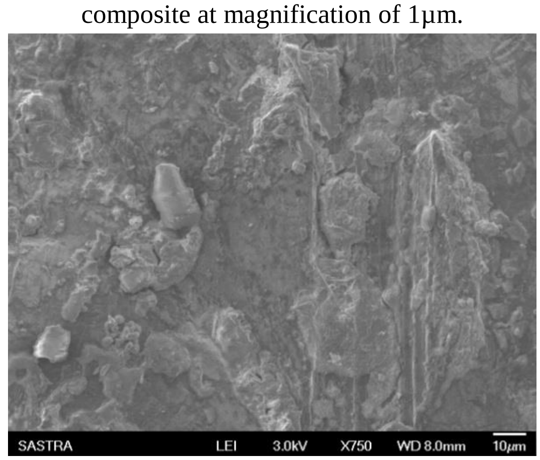


Fig. 3 SEM micrographs of AA6063-3 wt. % composite at magnification of 1µm.



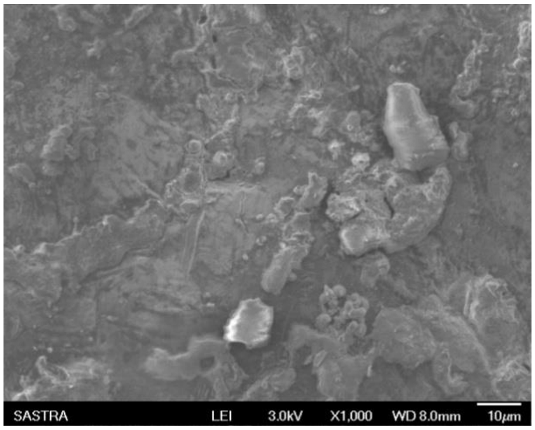


Fig.4 SEM micrographs of AA6063-3 wt. % composite at magnification of 10µm.

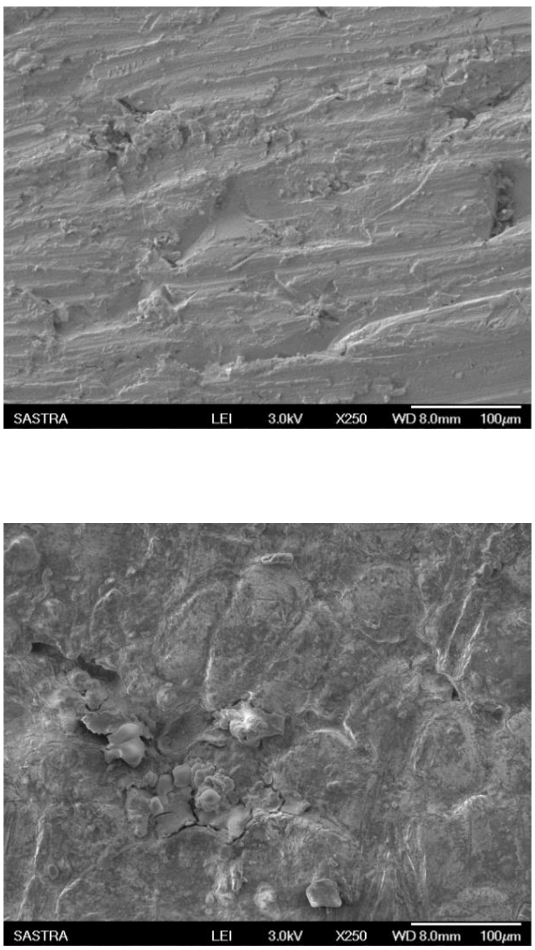


Fig.5 SEM micrographs of AA6063-3 wt. % composite at magnification of 100µm.

IV. CONCLUSIONS

The conclusions drawn from the present investigation are as follows:

- AA6063-3 wt. % composite have been successfully synthesized using stir casting technique.
- The uniform distribution of the reinforcement is seen in the microstructure of the AA6063-3 wt. % composite was carried out using optical microscope.

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