*Int. J. Chem. Sci.: 14(3), 2016, 1730-1736*
*ISSN 0972-768X*
*www.sadgurupublications.com*

# EXPERIMENTAL INVESTIGATION OF MECHANICAL BEHAVIOUR OF TIN ALLOY BASED PARTICULATE METAL MATRIX COMPOSITES

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## ABSTRACT

There is always a need for new engineering materials in the industry. Designers choose the materials based functional requirement and mechanical behaviour of the materials. In the present work, Tin alloy based particulate Metal Matrix Composite (MMC) with Ilmenite and SiC as reinforcements were fabricated. Stir casting was used for fabricating MMC. Then, its mechanical behaviour is investigated by conducting tensile test and hardness test. SEM images and microstructures were studied for understanding the behaviour. Two different Tin based MMC one with 1% SiC and another with 1% $FeTiO_3$ as reinforcements. Specimens were prepared according to the ASTM standard and tested. Uniform distribution of particles was observed and enhancement in the Ultimate Tensile Strength of Tin alloy by SiC compared to $FeTiO_3$.

**Key words**: Metal matrix composite, Ilmenite, Reinforcement, Stir casting, Hardness.

## INTRODUCTION

A composite material is a macroscopic combination of two or more distinct materials, having a recognizable interface between them. Composite is a multiphase material that exhibits significant proportion of the properties of both constituent phases such that a better combination of properties is realized. This is termed as the principle of combined action. The matrix in a metal matrix composite (MMC) is usually an alloy, rather than a pure metal. A metal matrix composite (MMC) is a composite material with at least two constituent parts, one being a metal. The other material may be a different metal or another material, such as a ceramic or organic compound. The need for composite materials has become a necessity for modern technology, due to the improved physical and mechanical properties. Metal matrix composites (MMC) have been developed in recent years. Metal matrix composites have

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emerged as a class of material capable of advanced structural, aerospace, automotive, electronic, thermal management and Wear applications. A composite material is a material consisting of two or more physically and/or chemically distinct phases. The composite generally has superior characteristics than those of each of the individual components. Usually, the reinforcing component is distributed in the continuous or matrix component. When the matrix is a metal, the composite is termed a Metal-Matrix Composite (MMC).

Combining high specific strength with good corrosion resistance, metal matrix composites (MMCs) are materials that are attractive for a large range of engineering applications. Given the factors of reinforcement type, form, and quantity, which can be varied, in addition to matrix characteristics, the composites have a huge potential for being tailored for particular applications. One factor that, to date, has restricted the widespread use of MMCs has been their relatively high cost. This is mostly related to the expensive processing techniques used currently to produce high quality composites. In this paper, the relatively low cost stir casting technique is evaluated for use in the production of silicon carbide/aluminium alloy MMCs. The technical difficulties associated with attaining a uniform distribution of reinforcement, good wettability between substances, and a low porosity material are presented and discussed[1].

Particulate reinforced magnesium matrix nanocomposites fabricated by semisolid stirring assisted ultrasonic vibration were subjected to extrusion. The results showed that grains of matrix in the SiCp/AZ91 nanocomposites were gradually refined while the amount of SiC nanoparticle bands was decreased with the extrusion temperature increasing from 250 to 350 °C. Under the same extrusion conditions, the grain size of the matrix was gradually decreased while the distribution of SiC nanoparticles was improved in the extruded nanocomposites fabricated by decreasing the stirring time. The yield strength and ultimate tensile strength of the nanocomposites were gradually enhanced with increasing the extrusion temperature. Significant improvement of tensile strength was obtained in the nanocomposites fabricated by decreasing the stirring time[2].

Manufacturing of aluminum alloy based casting composite materials via stir casting is one of the prominent and economical route for development and processing of metal matrix composites materials. Properties of these materials depend upon many processing parameters and selection of matrix and reinforcements. Literature reveals that most of the researchers are using 2, 6 and 7xxx aluminum matrix reinforced with SiC particles for high strength properties whereas, insufficient information is available on reinforcement of "$Al_2O_3$" particles in 7xxx aluminum matrix. The 7xxx series aluminum matrix usually contains Cu-Zn-Mg. Therefore, the present research was conducted to investigate the effect of elemental metal such as Cu-Zn-Mg in aluminum matrix on mechanical properties of stir casting of aluminum composite materials reinforced with alpha "$Al_2O_3$" particles using simple foundry melting alloying and casting route.

The age hardening treatments were also applied to study the aging response of the aluminum matrix on strength, ductility and hardness. The experimental results indicate that aluminum matrix cast composite can be manufactured via conventional foundry method giving very good responses to the strength and ductility up to 10% "$Al_2O_3$"particles reinforced in aluminum matrix[3].

In the present work, Al (99.7) matrix nano composites were fabricated and characterized with the aid of stir casting. Ilmenite ($FeTiO_3$) nano particles synthesized by top down approach using high-energy wet ball milling process. Al (99.7) matrix reinforced with the Ilmenite ($FeTiO_3$) nano particles at 1 to 5 weight percent were fabricated with the help of stir casting. XRD characterization was carried out on nano particles showing the least particle size. SEM images of cast composites shows the uniform distribution of nano particles in the Al matrix. The results were analyzed and found that the composites reinforced with 5 wt percent nano particles cast at $850^0$C have homogeneity in micro structures and exhibit'sincreased mechanical properties like hardness and tensile strength[4].

Investigation on stir casting route has been used for incorporating zircon sand particle of different size and amount in Al-4.5 wt% of alloy melts and their findings showed improved abrasive wear characteristics. In the present investigation, nanoparticles Ilmenite was used as rein for cement for the fabrication of Al-Ilmenite nano composites by stir casting technique. Nano particle Ilmenite synthesized by high energy ball mill via top down method. Microstructure and mechanical properties of the base alloy and the composites were studied[5].

Thus the aim of present paper is to fabricate Tin alloy based particulate metal matrix composite by stir casting method with Ilmenite and SiC as rein for cements. Investigate its mechanical behavior by conducting tensile test and hardness tests. Study SEM images and Microstructure for clearly understanding the behavior of the material.

## EXPERIMENTAL

### Material selection

A most common Tin based alloy was chosen as Matrix for the composite is as shown in Fig.1. It finds its application in many areas like automotive, ship board industries. High tin content in Babbitt is used in high speed and low pressure applications because of its light weight and hardness properties.

**Fig. 1: Tin alloy (Matrix phase)**

Reinforcement intended to increases the strength, stiffness and the temperature resistance capacity and lowers the density of MMC. In order to achieve these properties, the selection depends on the type of reinforcement, its method of production and chemical compatibility with the matrix. MMC reinforcements can be metallic, such as tungsten and cobalt; non-metallic, most often carbon or boron; or ceramic, silicon carbide (SiC), Aluminum oxide ($Al_2O_3$), boron nitride, tungsten carbide, titanium diboride. Here, the reinforcement material is Ilmenite, which is dense and highly porous. It finds applications in a variety of industries.

## Preparation of raw materials

## Preparation of matrix and reinforcement material (Ilmenite)

The tin-base babbitt pieces were sized to the according to the requirement and convenience for its melting in the furnace. The Ilmenite was crushed in planetary ball milling machine for about five minutes in order to get the even sizing of the material. Then the ball milled ilmenite was sieved using three different sieves of sizes such as 74 microns, 53 microns and 38 microns.

## Fabrication of stirrer blades

Stain steel material is used for fabricating the blade setup with four blades and twist angle of 60°. Gas welding is used for fitting the blade to the stirrer rod. As Tin material is at low melting point the withstanding, the material can't easily react with the blade the life period of blade will be more. The fabricated set-up is shown in Fig. 2 and with stirrer setup is shown in Fig. 3.

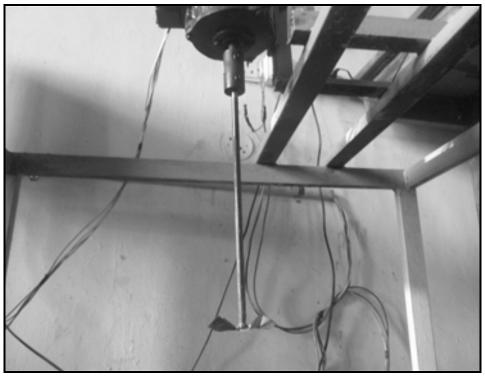

**Fig. 2: Experimental stirring arrangement**

**Fig. 3: Furnace set-up with stirrer**

**Procedure of starting of furnace and stirrer setup**

- Set the temperature to 421$^{o}$C now and maximum temperature to 450$^{o}$C in PID controller
- Heat the alloy to reach the melting point.
- Switch on the pre heating furnace and set the pre heating temperature to 400$^{o}$C in order to pre heat the Ilmenite.
- After reaching the required temperature of 450$^{o}$C, pre heated particles are added to the molten metal and stirrer is dipped in it.
- Set stirrer speed to required rpm using VFD.
- Check for eccentric motion of stirrer and correct if any.

**Fabrication of metal matrix composite**

The method chosen for fabricating Babbitt-ilmenite Metal matrix composite (MMC) is stir casting. This is because the processing expenses are low and also a better method to achieve dispersion in a low time and cost. The process of fabrication also includes pre-heating of die. Here we used a cast iron die, which facilitates two kinds of cavities.

## RESULTS AND DISCUSSION

Table 1 shows tensile test and hardness results.

**Table 1: Tensile test and hardness results**

| Run order | Specimen | Speed (rpm) | Time (min) | Stress at elastic limit (MPa) | Ultimate strength (MPa) | % of Elonga-tion | % or Reduction in area (R4) | RHN |
|---|---|---|---|---|---|---|---|---|
| 1 | Tin alloy | - | - | 35 | 67 | 5 | 7.84 | 78.3 |
| 2 | Tin alloy + SiC | 300 | 1 | 26 | 71 | 5 | 15.36 | 82.6 |
| 3 | Tin + Ilmenite | 300 | 1 | 31 | 56 | 1 | 0 | 71.6 |

## CONCLUSION

### Tin with ilmenite

TIN based alloy reinforced with micro sized Ilmenite was successfully produced via stir casting method. The following conclusions can be made based on the experimental studies carried out:

- Stir casting can be a promising and economically viable route for the production of particle reinforced MMCs.
- Stress at elastic limit is significantly affected by the stirring time and stirring speed.
- The ultimate stress is significantly affected by time than the speed. As time increases ultimate strength also decreases.
- % elongations in length and % reduction in area are not significantly affected by the factors time and speed.
- Hardness is not significantly affected by time and speed of the stirring process.

### Tin with silicon carbide

TIN based alloy reinforced with micro sized silicon carbide was successfully produced via stir casting method. The following conclusions can be made on the experimental studies carried out:

- Tensile strength is improved by reinforcing Tin with the Silicon carbide.
- Considerable change in hardness is also observed in this composite when compared with other two specimens.

- % Elongations in length and % reduction in area are affected and the values are changed in this specimen.

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*Accepted : 12.05.2016*