Tensile and Impact behaviour of Al-Silica Metal Matrix Composites

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ABSTRACT

In this study, Al alloy LM13-Silica composites were produced by stir casting method using silica powder as reinforcement particle with 150 micron average diameter and Al alloy as the matrix metal. Different samples of 3, 6, 9 and 12 weight percent of silica were prepared to investigate the effect of silica particles on the tensile and impact behavior. The casted composite specimens were machined as per test standards. Recently, the material technology has seen many contemporary developments in the field of fabricating new materials which reinstates the current materials for different applications. The manufactured composites were tested to determine their tensile and impact properties and the result proves that the samples addition of silica has better mechanical properties. The microstructures of the composites were studied to know the dispersion of the silca particles in matrix. This study essentially focuses on establishing aluminium metal matrix composites on aerospace and automotive industries applications because of their admirable properties compared with the unreinforced alloys.

Keywords: Silica particle, Al alloy, mechanical properties, stir casting.

1. INTRODUCTION

Aluminium is the world‘s most abundant metal and is the third most common element, comprising 8% of the earth's crust. The versatility of aluminium makes it the most widely used metal after steel. After iron, aluminium is now the second most widely used metal in the world. This is because aluminium has a unique combination of attractive properties. Low weight, high strength, superior malleability, easy machining, excellent corrosion resistance and good thermal and electrical conductivity are amongst aluminum's most important properties [1]. The need for Metal Matrix Composites (MMCs) has been expanding tremendously in recent days. Like all other composites, the MMCs too consist of distinct physical and chemical properties, where the matrix and the reinforcements were evenly distributed to maintain the property that cannot be obtained by individual phases or monolithic alloys.

Because of its good mechanical properties like enhanced hardness, high specific strength and specific modulus, aluminum base metal matrix are used in aerospace and automobile industries for manufacturing cylinder liners, pistons, connecting rods, turbochargers, bearings etc.,[2]. Metal matrix composite (MMC's) is engineered combination of the metal (Matrix) and hard particle/ceramic (Reinforcement) to get tailored properties. MMC's are either in use or prototyping for the space shuttle, commercial airliners, electronic substrates, bicycles, automobiles, golf clubs, and a variety of other applications[3-4].

A good combination of high strength and ductility of the Aluminum based metal matrix composites (MMC's) have introduced the material to a wide area of possible advanced applications. In general stir casting of MMC's involves producing a melt of the selected matrix material, followed by introducing reinforcement material into the melt, obtaining a suitable dispersion through stirring. Its advantages lie in its simplicity, flexibility and applicability to large scale production. It is also attractive because, in principle this method suitable for engineering application in terms of production capacity and cost efficiency [5]. Aluminium is the most popular matrix for the metal matrix composites. Aluminium is quite attractive due to its low density, their capability to be strengthened by precipitation, good corrosion resistance, high thermal and high electrical conductivity and damping capacity. The demand for structural materials to be cost effective and also to provide high performance has resulted in continuous attempts to develop composites as serious competitors to the traditional engineering alloys[6]. In the recent years, usage of ceramic particle - reinforced metal matrix composites (MMC's) is steadily increasing because of their advantages like isotropic properties and the possibility of secondary processing facilitating fabrication of secondary components.[7].

Al alloy composites have the potential to replace other costlier material in many significant engineering applications. The requirements concerning safety and reliability are always increasing and therefore the mechanical properties are ever more crucial[8].

2. MATERIALS AND METHODOLOGY

In this study aluminium alloy LM13 used as a matrix material and silica of average 150 micron size as particulate reinforcement with different percentages (in wt.% 3, 6, 9 and 12) based on the variation in weight. The composites were prepared by using stir casting method. Cast iron permanent mould is used for processing composite castings. The melt composites were stirred, then casted into a metallic mold. Figure 1 shows the pouring and stirring of reinforcement in stir casting method. The test specimens of the composites are prepared according to ASTM standards. The chemical composition of matrix material LM13 alloy is shown in table 1. Silica will give excellent hardness property when it is incorporated into the soft alloys, thereby making it better suited for applications where hardness is desirable. The table 2 shows different properties of reinforcenment silica.

Figure 1: Pouring and stirring of reinforcement in stir casting method

Table 1: Al alloy LM13 Chemical Composition

Elements	Zn	Mg	Si	Ni	Fe	Mn	Al
Wt. %	0.5	1.4	12	1.5	1.0	0.5	Bal.

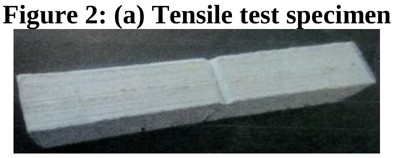
Table 2: Properties of reinforcement silica

Properties	**SiO_2**
Tensile strength	25 N/mm^2
Density	2.65 gm/cm^3
Melting Point	1830^{0}C
Compressive strength	2070 N/mm^2

3. PROCEDURE FOR TESTING PREPARED COMPOSITES

The cast composites were machined and the specimens for the measurement of tensile strength and impact behavior was prepared as per the ASTM standards. The tensile strength (E8) properties were evaluated in BISS, Banglore and Impact test (E23) properties were evaluated in KIT, Tiptur. The specimens prepared for tensile test and impact test as shown in figure 2.

Figure 2: (a) Tensile test specimen



(b) Impact test specimen

4. RESULTS & DISCUSSION

4.1 Microstructure Examination:

Microstructure is visualized with the help of optical microscope. The microstructure of the prepared composite for different weight percentage of reinforcement as shown in figure 3. These microstructures of the MMC's showing that the reinforcement particles are uniformly dispersed in the aluminium alloy matrix.

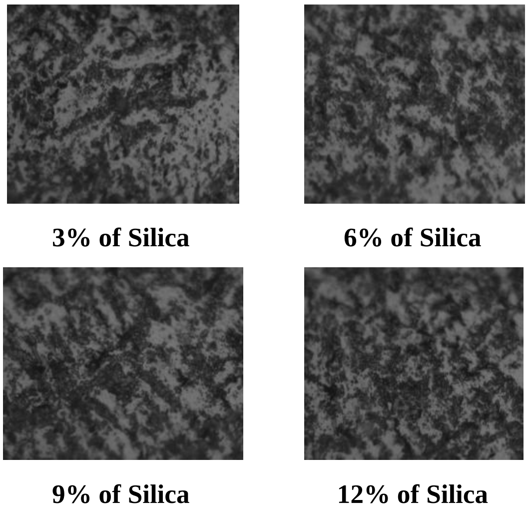


Figure 3: Microstructure of prepared composite with different weight percentage of reinforcement

4.2 Tensile Test

The Table 3 shows the tensile strength results obtained from tensile test for the prepared composites. The tensile strength increased with increased wt.% of reinforcement silica. Because the increase in the percentage of silica particulate reinforcement content would create more sites for crack initiation and hence lower down the load bearing capacity of the composite and the bonding between silica particulate increases with the base aluminum alloy matrix. The value of tensile strength for varying % of silica is shown in figure 4.

Table 3: Tabulated Tensile Strength values of the prepared composites

Wt. % of SiO_2	Tensile Strength (MPa)
3	171
6	182
9	191
12	189

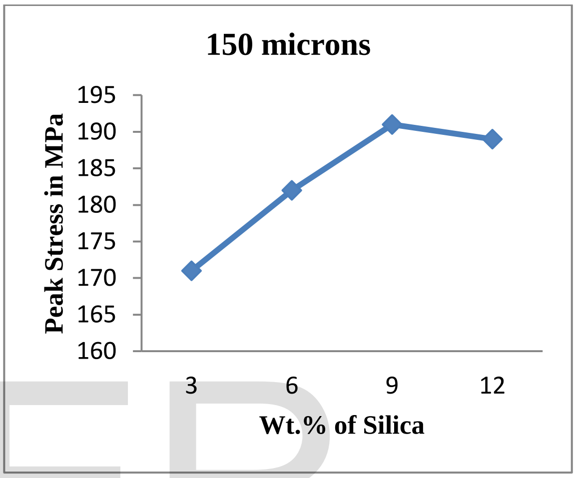


Figure 4: Tensile Strength value v/s Wt. % of Silica

4.3 Impact Test

The strength, ductility and toughness of material are modified when impact loads are used instead of static loads. Toughness is a measure of the energy that the material absorbs during plastic deformation before its failure under impact loading. The impact tests were done on the samples using Charpy test as ASTM E23 standards. The values for the impact tests have been given in Table 4 and it’s been clear that the sample with varying weight percentage of Silica absorbs more energy than base alloy.

Table 4: Tabulated Impact Energy value of the prepared composite

Wt. % of SiO_2	Impact Energy (N-m or Joules)
3	2
6	2
9	5
12	6

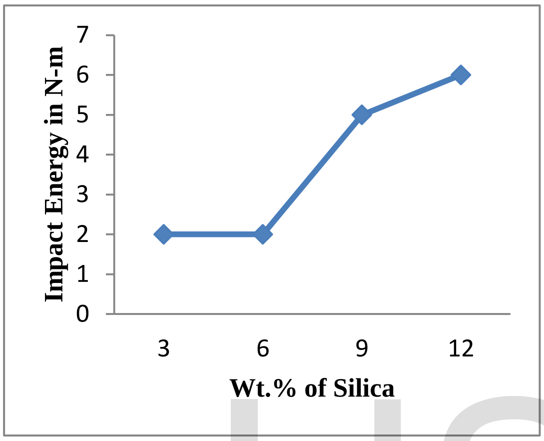


Figure 5: Impact Energy value v/s Wt. % of Silica

5. CONCLUSIONS

1. Stir casting method were successfully adopted in the preparation of Al alloy LM13-Silica composites.
2. Microstructure images shows the uniform distribution of reinforcement silica and bonding between matrix and reinforcement material.
3. Tensile strength was increased up to 9 weight percentage silica, after that decreased.
4. Impact energy was increased with the addition of reinforcement material silica.
5. Finally it can be concluded that Al alloy LM13-Silica exhibits superior mechanical properties when compared with base alloy.

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