Development of Al alloy LM12/Sic by using stir casting Technics and Characterization of Tensile properties

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Abstract

Metal matrix composites of aluminum alloy with silicon carbide reinforcement are useful in aerospace, automobile and general engineering industries because of their favourable microstructure and mechanical behavior. Composites of aluminum alloy LM12 and silicon carbide were fabricated by using stir casting technique. Compression and tensile test conducted, a significant improvement in material strength is observed in aluminum alloy LM12 metal matrix composite as compared to the alloy without silicon carbide addition. Cast base metal and its composites were found to fairly predominantly in brittle mode during the Compression and tensile test. During, casting silicon carbide, the content composites varies 0 to 20% Weight. Casting technique and characterization of aluminum alloy LM 12 and silicon carbide metal matrix composite (MMC) are described in the present paper.

Keywords: SiC, LM12, MMC's, and Tensile test.

1.0 Introduction

Metal matrix composites are obtained by reinforcement of ceramic particles to a base metal to realize improvements in properties (1-5). The reinforcements can be in the form of different types like fibers, whiskers and particulates forms (6-8). To achieve the required properties of MMC-reinforcement material, fabrication method, varying percent and % volume can be followed to make it suitable of industrial use. Because of their superior strength and hardness metal matrix composites are replacing monolithic materials in aerospace as well as automobile industries. (9-13).

Present work describes the microstructural and mechanical properties of LM12 Aluminum alloy and silicon carbide MMC's reinforced with different %wt of SiC particles.

The matrix alloy LM12 employed presently for the development of the composite is an aluminum copper alloy. The composition of the alloy is as given below:

Element	Wt.%	Element	Wt%
Copper	09-11	Zinc	0.8 max
Magnesium	0.2-0.4	Lead	0.1 max
Silicon	2.5 max	Tin	0.05 max
Iron	1.0 max	Titanium	0.2 max
Manganese	0.6 max	aluminum	Balance
Nickel	0.5 max		

2.0 Development of MMC by Stir Casting

Process Composite was done by a stir casting process as shown schematically in Fig:2.1

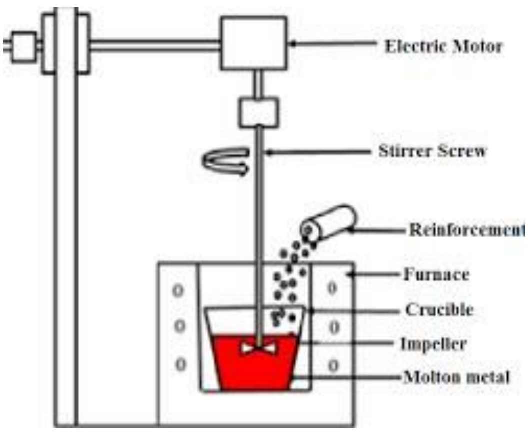

Fig:2.1

Fig:2.2 Schematic of Stir Casting Process and
Fig:2.2 Cast Base Metal /Composite

The stir casting technique is the process of stirring the molten metal continuously by a stirrer using Electric motor. Stirrer is immersed 1/3rd portion into the molten metal which is heated in a crucible which is made up of graphite material. Continues heat supplied to crucible by an electric heating source. Silicon carbide poured into the molten metal and stirred thoroughly to mix the reinforcement with the molten metal. Average stirring speed of 300 to 400 rpm and temperature of furnace approximately 700 to 750°C should be maintained up to duration.

Molten metal poured into the graphite mold cavity having diameter 20-25mm, and during this process temperate need to be consistently maintained 730 °C. Once molten metal pouring is completed into the cavity, this need to be cooled around 300 °C, to obtain LM12 MMC's. The specimen is machined and shaped as per ASTM D638 standards as shown in the figure:2.2. Specimen was prepared by considering dimensional ratios with 13 mm diameter, 50 mm gauge length, 76 mm radius of fillet.

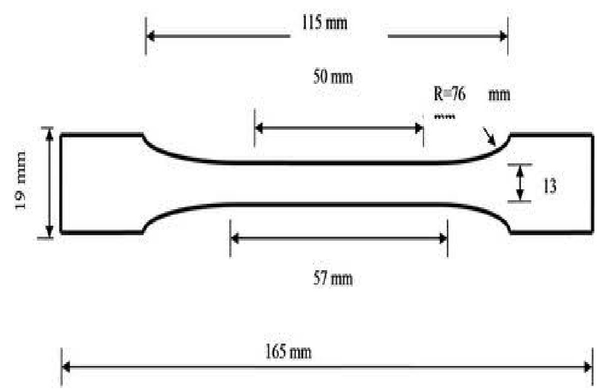

Fig:2.3 ASTM-D638 tensile specimen

3. Mechanical properties of tensile test

Total Length of the Specimen (L): 105mm

Diameter of Specimen (D):20 mm

Gauge Length of Specimen (l) = 35mm

Diameter of Specimen (d) =8.9 mm

Initial area = 62.21mm^2

Applied Load (P) = 4230.28N

Table:3.1

Sl. N o	Specimens	UTS (MPa)	0.2% Proof Stress (N/mm^2)	% EL	% RA
1	LM12	78	68	2.6	2.44
2	LM12+5% w SiC	87	78.5	2.1	1.94
3	LM12+10 %w SiC	87	79	2.2	1.96
4	LM12+15 %w SiC	103	93	1.9	1.79
5	LM12+20 %w SiC	106	95	1.6	1.67

3.1 Tensile Test data analysis

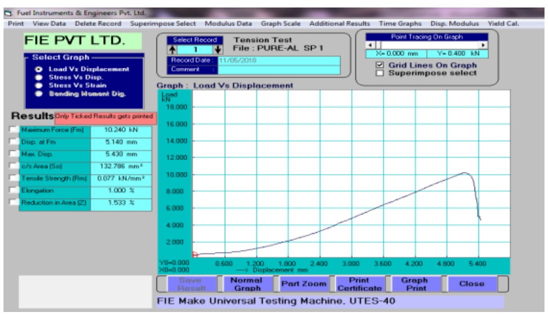

Fig:3.1 LM12 pure (Load v/s Displacement)

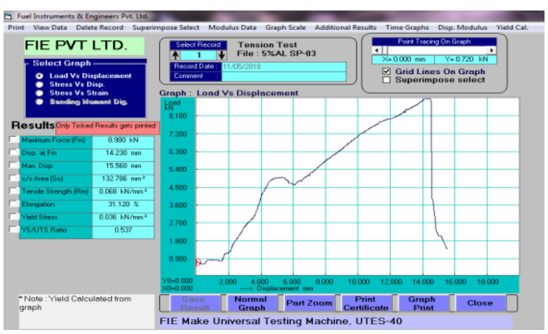

Fig:3.2 LM12+5%Sic (Load v/s Displacement)

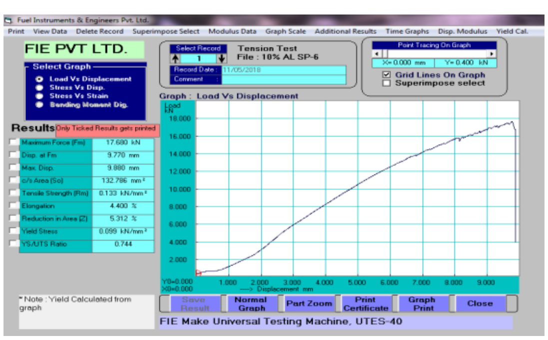

Fig:3.3 LM12+10%Sic (Load v/s Displacement)

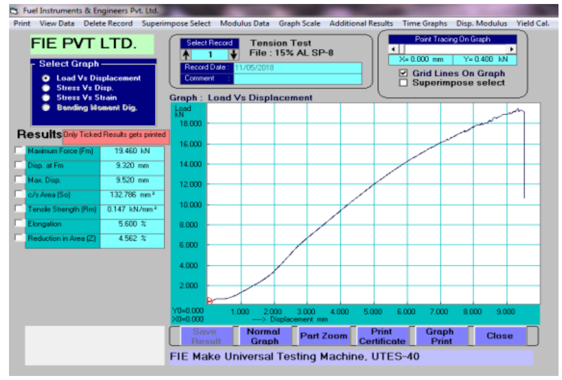

Fig:3.4 LM12+15%Sic (Load v/s Displacement)

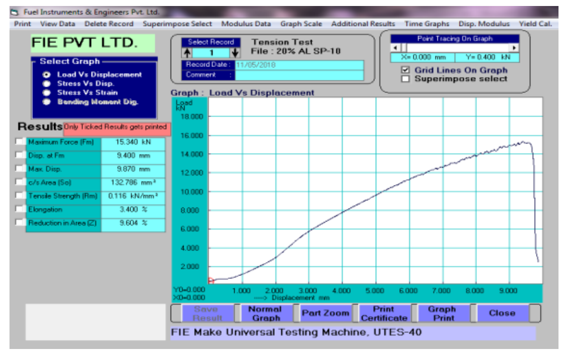

Fig:3.5 LM12+20%Sic (Load v/s Displacement)

Fig:3.6 Fractured tensile specimens

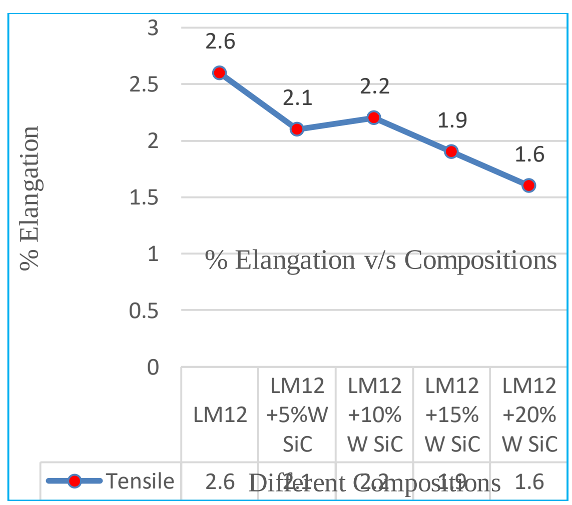

Fig:3.7

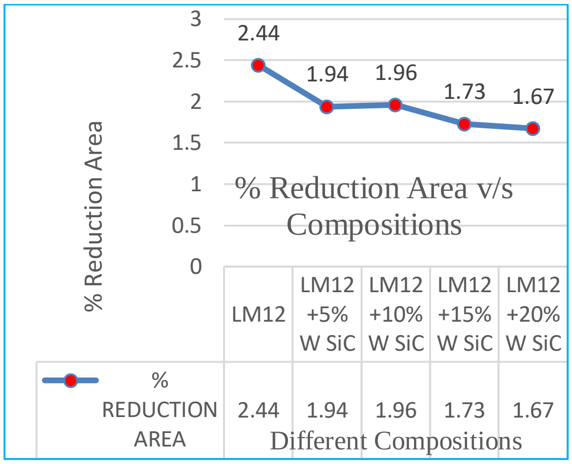

Fig:3.8

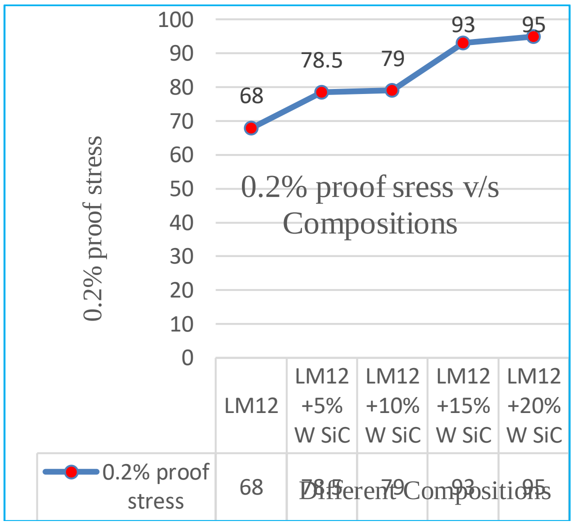

Fig:3.9

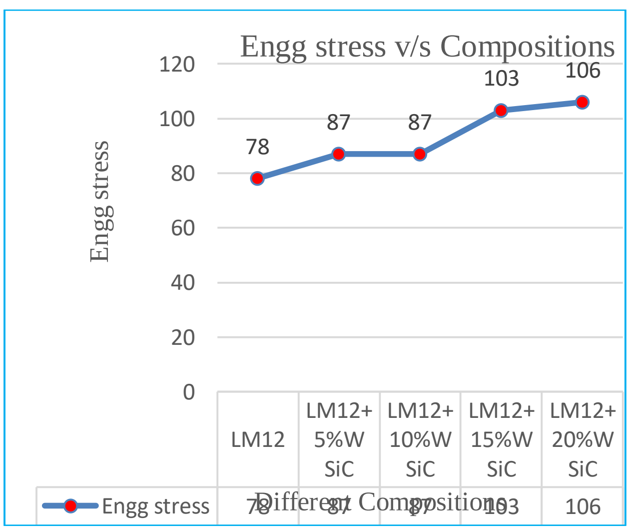

Fig:3.10

3.2 Results and discussions

The tensile test specimens were prepared as per the ASTM D638.Tensile tests were carried out by using a UTM.

Tensile test data in table 3.1 reveals an increase in UTS and Proof stress with enhanced SiC content.

A decreasing trend is observed in respect of % elongation and reduction in area (RA). The trend observed is in line with the observation that enhanced ceramic (SiC) content in the matrix leads to low ductility in the material.

Literature review (13) indicates that increase in strength is realized up to a certain critical level of reinforcement. Beyond this level decreases in strength have been reported. Explanation for the observed trend is based on dislocation mechanism in the material. Enhancement in strength is associated with restrictions on the dislocation mobility due to pinning (14) by fine dispersed particles. When the particle size increases beyond a critical value, dislocations shear through the particles and the resultant enhanced mobility leads to decreases in strength (14-15). The critical size contributing to reduction in strength has been found to vary with the nature of particle dispersed in the matrix. The phenomenon observed here is akin to averaging observed in precipitation hard enable alloys (16-19).

Enhancement in strength of the composite up to 20% SiC content appears to indicate that the critical value of SiC level which contributes towards decrease in strength is likely to be above this value. This aspect needs to be corroborated by further work and analysis.

A significant decrease in percent elongation and reduction in area may be associated with cast aluminum alloy LM12.

Used for the present work. Further reduction of these properties observed in the composites is attributable to enhanced brittleness of the material following the additions of SiC reinforcement.

4. Conclusions

Composite of aluminum alloy LM12 and silicon carbide was successfully fabricated by using a stir casting technics and conducted tensile test. Microstructure of the composite revealed a fairly uniform distribution of silicon carbide in LM12 matrix. Silicon carbide reinforcement enhanced the hardness of the composite. With increasing reinforcement contents an increases the engineering proof stress and ultimate tensile stress of LM12 MMC's. This results may leads to increases hardness of MMC's could be attributed to dispersion hardening resulting from the reinforcement particle aggregate.

Following increase in hardness of LM12 MMC's an improvement in strength and reduction in percent elongation and reduction of area were noticed in the graphs.

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