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A Study on Effect of SiC on Mechanical Properties of Aluminium 8011 Metal Matrix

Mr. M. Tamilarasan[1], Dr. P. S. Sampath[2]

[1]PG Scholar, Dept. of MECH, K.S.Rangasamy College of Technology, Tiruchengode, Tamilnadu, India
[2]Professor Dept. of MECH, K.S.Rangasamy College of Technology, Tiruchengode, Tamilnadu, India

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Abstract - *This study deals with the preparation of (AA8011-SiC) composite. Stir casting technique was employed on a induction furnace to fabricate the aluminium composite specimen by varying alumina particles in 3, 5 and 7% by weight. Meanwhile the prepared specimen were exposed to hardness, tensile and flexural studies. Ultimate tensile strength of the composites decreased with increase in addition of SiC particles, while the hardness, tensile and flexural strength of composites increased with increase in SiC particles. The rapid rate of increase in tensile strength of the composites was observed initially but with the increase in the concentration of SiC particles this rate of increment was not too much. Brittle fracture of composites in the form of particle fracture and cracks are due to the strong interfacial bonding between the SiC particles and aluminium matrix at high strain rate. High impact strength of composite is due to ductile failure in the form of dimples whereas low impact strength is due to brittle failure in the form of micro and macro cracks, particle fracture.*

***Key Words*: Aluminium 8011 alloys, SiC, Metal Matrix Composites (MMC), aluminium matrix composites (AMC), Tensile, Hardness, Flexural.**

1. INTRODUCTION

Two or more materials with different chemical composition and essentially insoluble in each other are combined together to form a composite material. Hence it is a complex material system whose properties can be tailored as per the needs of mankind by varying its different constituents. Its classification predominantly used in industries involves metal matrix, polymer matrix and ceramic matrix composites. Metal Matrix Composites (MMCs) have received considerable attention of researchers due to their high specific strength, hardness, flexibility and stiffness compared to other conventional materials. They have found extensive application in automobiles and aerospace vehicles. tensile and hardness behaviour of the composite. Stir casting technique was used to fabricate the composite as this technique is popularly known for its simplicity, flexibility, ease of mass production and being cost effective. Out of different matrix materials available, Aluminium Matrix Composites (AMCs) are considered as best suitable candidates due to light weight and reduced processing cost and. In particular aluminium 8011 has attractive properties such as good cast-ability, corrosion resistance and higher strength to weight ratio etc.

1.1. Material Description

In this work, aluminium alloy (AA8011), shown in table 1 in the form of sheet of 150 mm length 50 mm width and 1.5 mm thickness were used as base material, while silicon Carbide particles with a particle size of (10) µm is used as reinforcement.

Table -1: Chemical Composition on Aluminium 8011

Material	Fe	Si	Mn	Al	Others
Weight%	1	0.9	0.2	97.5	1.4

1.2. Reinforcement

Since the objective of this work was to investigate the effect of weight fraction of reinforcement on tensile, hardness and flexural, proportion of SiC powders was varied in the range 3, 5 and 7% by weight. These powders were pre heated to 300°C before mixing. Silicon Carbide powder has physical properties like good electrical and thermal conductivity, temperature stability and high purity. It acts as solid lubricant and has low density.

2. EXPERIMENTAL WORK

As already mentioned Aluminium alloy 8011 was used as matrix material in this work for the production of the composites which was reinforced with 3, 5 and 7% by weight SiC particles of 10µm. The composite was fabricated by the two step stir casting method. The Aluminium 8011 alloy was kept in SiC and melted in resistance furnace at 680°C above its melting point (660°C) to remove entrapped gases, degassing tablet was used. While melting magnesium was added to improve wettability between molten metal and graphite partials and to facilitate the dispersion of particles into the alloy during melting. The metal was stirred continuously using steel stir. Stirring is done for about 300sec, the stirring speed is increased gradually up to 300rpm. Initially 3% by weight of SiC was added and later it was incremented by 2% till it reached 7%. The melt was then poured to a prepared Rectangular mould box of mild steel material at about the same melting temperature. The figures 1, 2 and 3 show the preheater, Stir casting furnace and casting die. The melt in the mould box was then cooled in still air. The tensile, hardness and flexural test specimens were then cut to the required dimensions as per ASTM standards.

Fig – 1 Induction Furnace

Fig – 2 Stir Casting Apparatus

Fig – 3 Casting Die

3. TESTING

3.1. Tensile Test

The prepared rectangular specimens were brought down to final dimensions as per ASTM E8 Standard by machining the specimens using conventional lathe machine. Tensile test was carried out using Universal Testing Machine. The tensile load was applied gradually from initial value of 0.5 KN till failure load. Ultimate tensile strength and % elongation obtained from tensile test are provided in table 2.

Table – 2 Tensile Test

Tensile	Peak Load (N)	% Elongation	UTS (N/mm^2)
AA8011-0%	3463.882	18.91	107.106
AA8011-3%	3759.354	21.84	109.931
AA8011-5%	3843.962	22.94	106.782
AA8011-7%	3604.233	20.47	100.121

3.2. Hardness

First the Rectangular specimens were cut to the required dimensions as per ASTM E384 - 17. The samples were polished by 400, 800, and 1200 grit paper, to get fine surface before testing their hardness. The hardness of prepared composite was measured by Micro hardness test. The hardness values were measured in 3 different locations over the surface of the samples, average value were calculated and are shown in table 2.

Table – 2 Hardness Test

Sample	Hardness
AA8011-0%	43.82
AA8011-3%	49.86
AA8011-5%	44.67
AA8011-7%	47.56

3.3. Flexural Test

First the Rectangular specimens were cut to the required dimensions as per ASTM E290. The Flexural of prepared composite was carried out by Universal testing Machine. The load was applied gradually from initial value of 0.5 KN till failure load. Peak load, flexural strength and flexural modulus obtained from flexural test are provided by table 3.

Table – 3 Flexural Test

Flexural	Flexural Strength (MPa)	Flexural Modulus (GPa)
AA8011-0%	191.114	2819.445
AA8011-3%	195.891	33921.46
AA8011-5%	193.197	34430.95
AA8011-7%	179.113	27721.21

4. RESULT AND DISCUSSION

4.1. Tensile Properties

The tensile test results furnished in table 2 show the increasing trend in the values of ultimate tensile strength with increase in reinforcing SiC % by weight. Hence it can be concluded that the presence of greater amount of SiC increases strengthening effect till 7%. The opposite trend is observed in case of % elongation. As the SiC content increases % elongation decreases. This is because SiC content increases the tensile strength. This shows that addition of SiC influences ductility levels of composites. Figure 4 shows Scatterplot of Ultimate Tensile Strength & Peak load Vs SiC %

wt. and figure 5 shows Scatterplot of % elongation Vs Sic % weight.

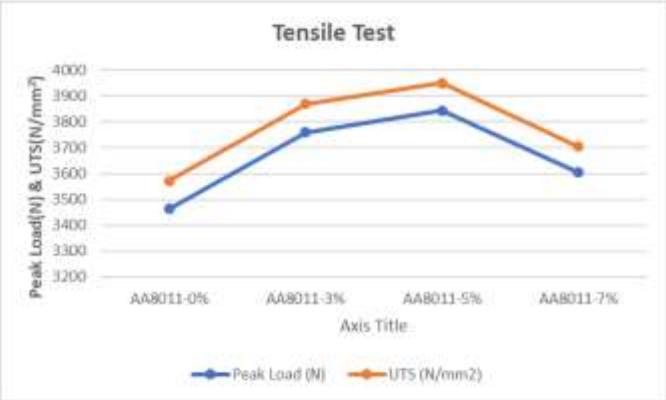

Fig – 4 Tensil Test Vs wt %

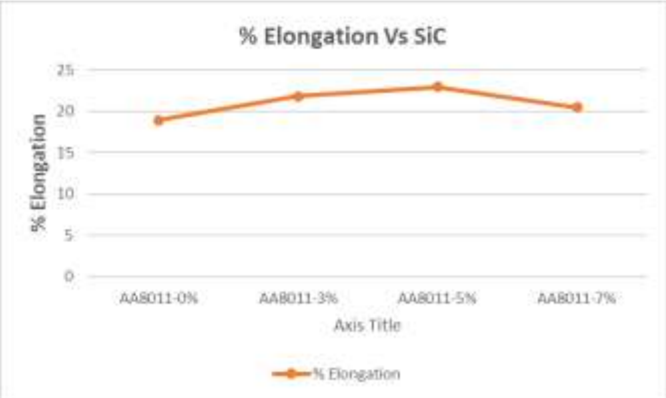

Fig – **5** % Elongation Vs wt %

4.2. Hardness

The values given in table 3 reveal that hardness of the composite increases proportionately with increase in the weight % of SiC particles in composite. This is depicted in Scatterplot drawn in figure 6.

Fig – 6 Hardness Test

4.3. Flexural Test

The flexural test results furnished in table 4 show an increasing trend values of Flexural strength and Flexural modulus with increasing the reinforcement of SiC % by weight. This is depicted in Scatterplot drawn in figure 7 and figure 8.

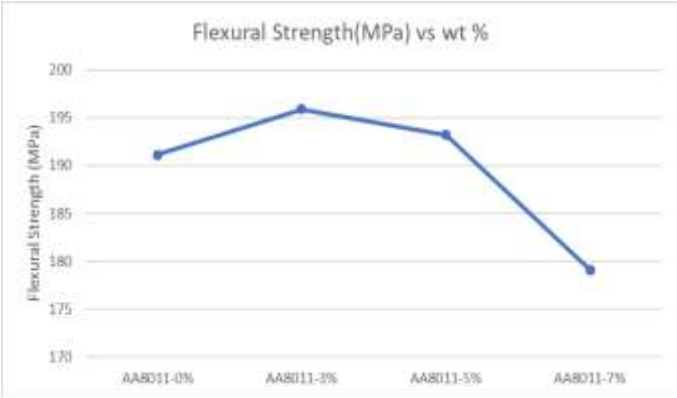

Fig – 7 Flexural Strength Vs wt %

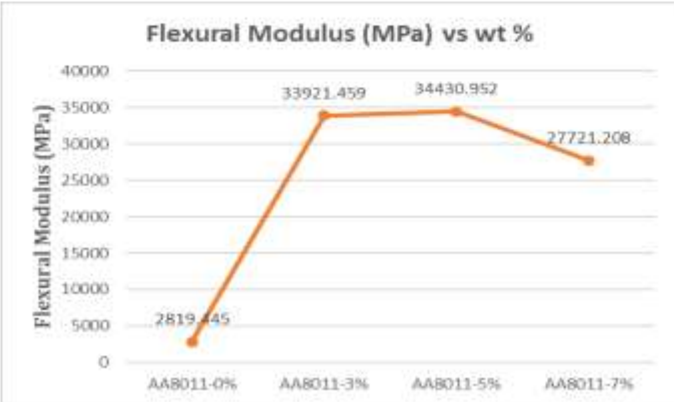

Fig – 8 Flexuaral Modulus Vs wt %

5. CONCLUSIONS

From the present experimental investigation the following conclusions may be drawn.

Aluminium 8011 alloy based metal matrix composite reinforced with fine particles of Silicon Carbide were successfully fabricated by two step stir casting method. Incorporation of Silicon Carbide as reinforcement increases upto 5% Ultimate Tensile Strength of Aluminum 8011 metal matrix composite when compared with base metal. And this strengthening is consistently increasing till 5% of Silicon Carbide. Accordingly % elongation increases with increases in Silicon Carbide 7%. Compared to base metal, addition of Silicon Carbide as reinforcement has positive effect on Hardness, Tensile strength and Flexural strength. Also as Silicon Carbide content increases, Hardness also increases proportionately.

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