A Review and Analysis of Mechanical Properties of Aluminium Silicon Carbide – Metal Matrix Composite

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ABSTRACT

Aluminium Silicon carbide alloy composite materials are widely used for a many number of applications like engineering structures, aerospace and marine application, automotive bumpers, sporting goods and so on. Present work is focused on the study of behavior of Aluminium with SiC particles composite produced by the stir casting technique. Different types of reinforcement's i.e. 0%, 5% and 15% of SiC are used. Hardness test is performed on the samples. In this study, reviewed and investigated the mechanical properties of Aluminium silicon carbide metal matrix composite and examine the values in LSDYNA analysis software. As % of SiC increases at certain level, the strength and hardness of the metal matrix composite material is increased.

Keywords: *Aluminium Silicon carbide (AlSi), Vickers Hardness, LSDYNA.*

INTRODUCTION

Aluminum based composite has been widely used in many fields owing to its excellent properties such as low weight, high special strength and stiffness, high electrical and thermal conductivity, low thermal expansion, good wear resistance and environmental corrosion resistance. It is generally prepared by dispersion of ceramic particle like SiC, Si3N4, A12O3 or TiC in Al matrix and the most commonly used particle is SiC [1]. Metal Matrix Composites (MMCs) are manufactured by various methods such as casting, diffusion bonding and powder metallurgy. In case of continuous fiber composites, powder metallurgy techniques cannot be used because of difficulties in achieving correct alignment in fibers, although problems relating to connectivity and continuity also exist . The other types of MMCs like discontinuous and particle reinforced can be made by the powder metallurgy; however, casting techniques may also be employed. The stir casting process is carried out by first liquefying the metal, then introducing the ceramic particles in the melt by different processes and at the end letting it to solidify on its own or by using controlled solidification mechanism [2].There have been tremendous strides in engineering materials since 1950s. Several super alloys and heat resistance materials have been developed for various industrial applications, especially aerospace/aircraft and defense. Automotive, medical and sport equipment industries pushed advances in materials further to introduce new generation materials particularly having low density and very light weight with high strength, hardness and stiffness. One of the important of these advanced materials is composites (Matthew and Rawlings, 1994) [3]. Composite materials are important engineering materials due to their outstanding mechanical properties. Metal matrix composite (MMC) materials are one of the widely known composites because of their superior properties such as high strength, hardness, stiffness, wear and corrosion resistances. Silicon carbide particle (SiC-p) reinforced aluminium-based MMCs are among the most common MMC and commercially available ones due to their economical production (Bedir and¨ gel, 2004) [4]. Designing metal matrix composite materials, to combine the desirable attributes of metals and ceramics. The addition of high strength, high modulus refractory particles to a ductile metal matrix produce a material whose mechanical properties are intermediate between the matrix alloy and the ceramic reinforcement. Aluminium is the most abundant metal in the Earth's crust, and the third most abundant element, after oxygen and silicon. It makes up about 8% by weight of the Earth's solid surface. Due to easy availability, high strength to weight ratio, easy machinability, durable, ductility and malleability, aluminium is the most widely used non-ferrous [5].

2. PROBLEM STATEMENT

Surface roughness of the AlSiC composite specimens, tool wear during machining of AlSiC composite materials, and strength of the AlSiC composite material is mainly affected by hardness at certain level, which is contributed wt. % of SiC (reinforcement).

3. OBJECTIVE

Objective is to review and analysis of mechanical properties of Al-SiC – MMC.

3.1 EXPERIMENTAL STUDIES

Vickers Hardness

Indentor = Diamond type

Load = 30 kgf

Formula

VHN = P (Load) ÷ (surface area of indentor)

$= P \div D^2 \div 2 \sin(\Theta/2)$

Where Θ is the angle of indentor = 136°

Table 1: Hardness test

% of SiC	Hardness
0	62.24
5	65.21
15	71.02

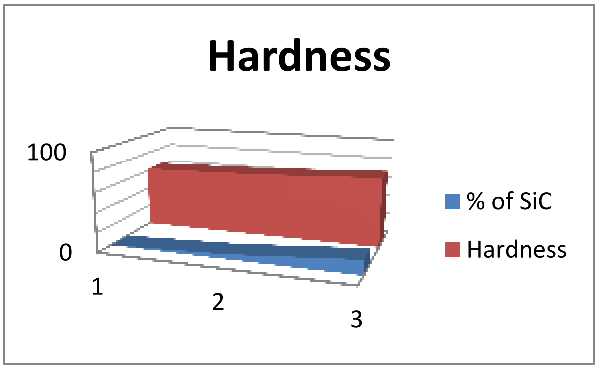


Figure 1: Effect of Percentage of SiC on Hardness of MMC

IMPACT TEST

Impact tests are designed to measure the resistance to failure of a material to a suddenly applied force. The test measures the impact energy, or the energy absorbed prior to fracture.

CHARPY TEST

While most commonly used on metals, it is also used on polymers, ceramics and composites. The Charpy test is most commonly used to evaluate the relative toughness or impact toughness of materials and as such is often used in quality control applications where it is a fast and economical test. It is used more as a comparative test rather than a definitive test.

Charpy test specimens normally measure 55x10x10mm and have a notch machined across one of the larger faces. The notches may be V-notch. A V-shaped notch, 2mm deep, with 45° angle and 0.25mm radius along the base.

CHARPY TEST RESULTS.

Table 2: Experimental results of Charpy test.

% of SiC	Energy absorbed (Nm)
0	6
5	9
15	10.5

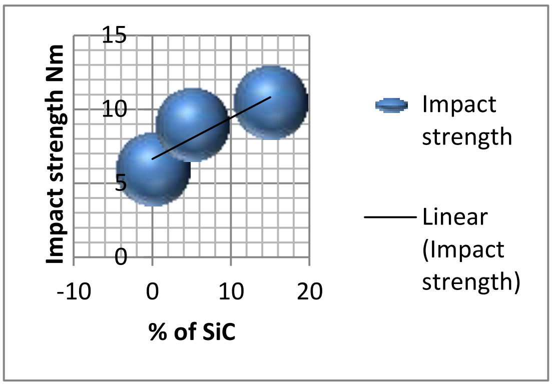


Figure 2: Effect of percentage of SiC on impact strength

IMPACT ANALYSIS

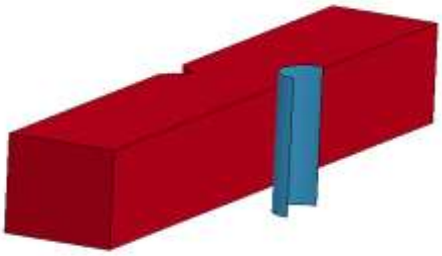


Figure 3: Impact model

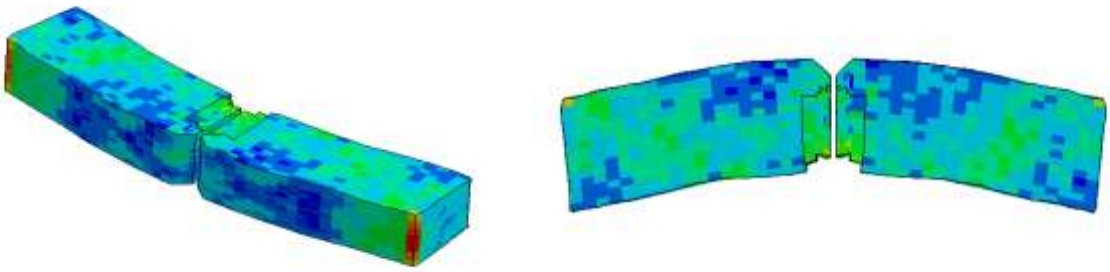
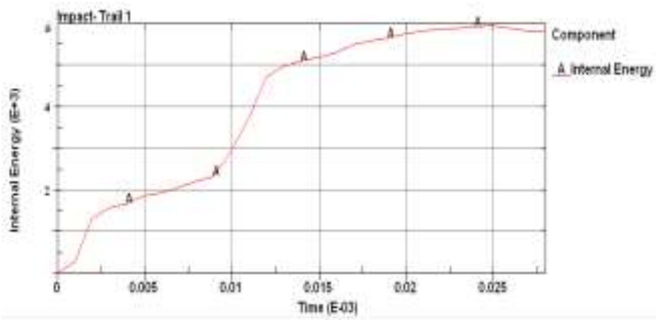


Figure 4: Impact analysis

Trail 1: Composites with 5 Percentage of SiC Trail 2: Composites with 5 Percentage 15% of SiC.



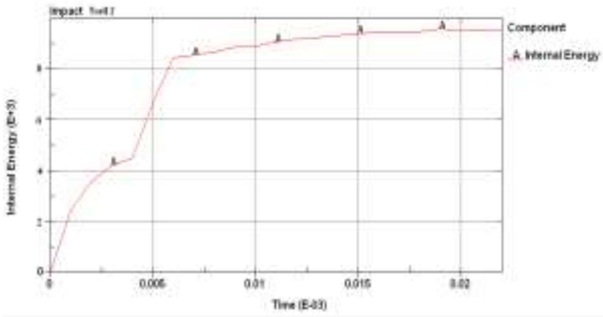


Figure 5: Internal energy **Figure 6: Internal energy**

MATERIAL PROPERTIES USED FOR ANALYSIS

Table 3: Material properties

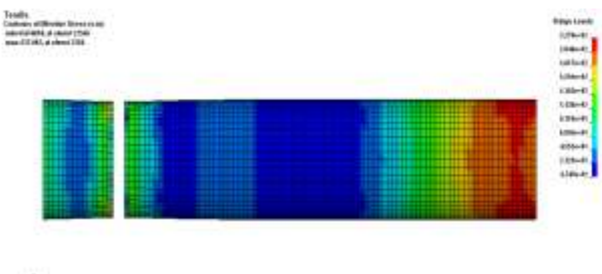
Tensile Stress N/mm^2	170
Youngs modulus	71E+3
Density	0.145 gms/cc

Figure 7: Tensile model

Table 4: Comparison results

TRAIL 1 (5% of SiC)	Experimental	LSDYNA analysis
Ultimate stress	216.47	227
Plastic strain % elongation	6%	7%

Trail 1: Load of 17 KN



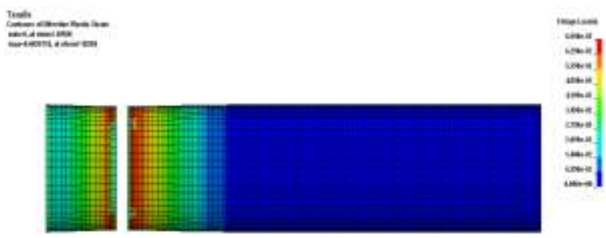


Figure 8: Contour of effective stress **Figure 9:** Contour of effective plastic strain

Table 5: Summary of Results

TRAIL 2 (15% of SiC)	**Experimental**	**LSDYNA analysis**
Ultimate stress	241.94	260
Plastic strain % elongation	4 %	15.9%

Trail 2: Load of 19 KN

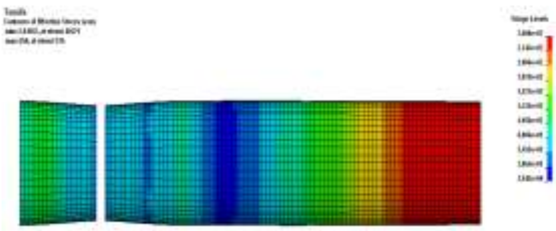


Figure 10: Contour of effective stress

Figure 11: Contour of effective plastic strain

CONCLUSION

SiC/Al composites can be made in an open atmosphere by stir casting using fabrication scheme derived from the literature review and mentioned in the experimental. In this study, hardness and analysis of mechanical characteristics of AlSiC reinforced with 0, 5 and 15 wt.% of SiC was examined. With the increase in reinforcement ratio, the impact strength and hardness of the aluminium silicon carbide metal matrix composite material is increased.

- For 5% of SiC, analysis gives the value of ultimate stress is 227 MPa and % of elongation is 7%.
- For 15% of SiC, analysis gives the value of ultimate stress is 260Mpa and % of elongation is 15.9%.

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