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Mechanical Behaviour of Al-6063 with SIC Composite Experimental Analysis

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Abstract: ***The mechanical properties of materials can be increased with composite application. Reinforcement of Aluminium alloy can increase it value in aerospace, automobile, marine and construction industries. This study analysed the mechanical behaviour of reinforced aluminium alloy matrix with silicon carbide composite. The reinforced mechanical properties were examined at the ratio of 5%, 7% and 9% silicon carbide particles. The effect of different weight percentage of silicon carbide on aluminium alloy composite was studied for Tensile strength, Hardness and Microstructure. It was observed that the Hardness & Tensile strength of the composites increased with increasing reinforcement element addition in it. The distribution of silicon carbide particles was uniform in aluminium.***

Keywords: Silicon carbide, Aluminium alloy, Mechanical properties, Hardness

1. Introduction

It is important to state here that out of 1600 engineering materials available in the market today, over 200 are composite [1]. Aluminium metal matrix composites (AMMCs) have considerable applications in aerospace, automotive and military industries due to their high strength to wear ratio, stiffness, light weight, good wear resistance and improved thermal and electrical properties. Ceramic particles such as Al_2O_3 and SiC are the most widely used materials for reinforcement of aluminium [2, 3]. Metal matrix composites (MMCs) are one of the important innovations in the development of advanced materials. Among the various matrix materials available, aluminium and its alloys are widely used in the fabrication of MMCs and have reached the industrial production stage. The emphasis has been given on developing affordable Al-based MMCs with various hard and soft reinforcements (SiC, Al2O3, zircon, graphite, and mica) because of the likely possibilities of these combinations in forming highly desirable composites [4].

Aluminium 6063is a medium strength alloy commonly referred to as an architectural alloy. The chemical composition of Aluminium 6063 are Al (96.5%), Si(0.2-0.6%), Fe(0.35%), Cu (0.1%), Mn (0.45-0.9%), Mg (0.45-0.9%), Cr (0.1%), Zn (0.1%), Ti (0.1%) and others(0.15%). It is normally used in intricate extrusions. It has a good surface finish, high corrosion resistance and can be easily anodized which makes it suitable for welding. It is commonly available as T6 temper. It has good formability in T4 condition. The 6xxx-group alloys have a widespread application, especially in the building, aircraft, and automotive industry due to their excellent properties [5].

Silicon Carbide is the only chemical compound of carbon and silicon. It is originally produces by a high temperature electro-chemical reaction of sand and carbon. The material is currently been developed into a high quality technical grade ceramic with very good mechanical properties [6]. Today, SiC is still produced via a solid state reaction between sand (silicon dioxide) and petroleum coke (carbon) at very high temperatures in an electric arc furnace.

2. Experimental Procedure

The metal matrix composites were prepared by stir casting process in Hariom precision casting pvt Ltd. The materials used for the experiment are Aluminium liquid, Electric motor, Sic particles, Insulated board, Blades and Crusible. Al–SiC composite with varying SiC percentage were prepared by melting commercially pure aluminium and commercially pure silicon in a 220 mesh particle in a high frequency induction furnace and the melt was held at 680 °C in order to attain homogeneous composition.

2.1 Tensile Test Process

In any design work, it is important to consider practically realizable values of strength of the materials used in design. The tension test is one of the basic tests to determine these practical values. The range of values obtained from the tests forms the basis for the size of the material in the products for the factor of safety. The tension test is conducted on a universal testing machine at room temperature [7]. The original gauge diameter and gauge length of the specimen were measured with Vernier calliper & steel rule respectively. Dot punch was used to mark the gauge length by two tiny dots. The test sample was thereafter subjected to Universal Testing Machine to ascertain the Tensile strength and Yield strength.

2.2. Hardness Test Process

Hardness measurement was carried out on the base metal and composite sample by using Brinell hardness machine. The applied load was 500 kg and indenter was a steel ball 10 mm in diameter. In this test a standard hardness steel ball of diameter D was pressed for about 10-15 seconds into the surface of the specimen by a gradually applied load P. The impression of the steel ball was measured to nearest 0.2 mm with the help of microscope. The Brinell hardness number was obtained by dividing the applied force by the spherical surface area of the indentation [8]. The diameter of the indentation was measured after the load and ball have been removed.

2.3. Microstructure Test Process

Microstructure studies were conducted in order to study the distribution of SiC particles retained in the metal matrix. Microstructure examination was generally performed using optical or scanning electron microscopes to magnify features of the material under analysis [9]. In order to identify and evaluate the microstructure of material, it is very important toprepare the test sample. Characterization was done in etched condition. Microstructures of the alloy samples wereobserved under inverted metallurgical microscope. The Al-SiC samples of different weight composition were mechanically polished using standard metallographic techniques before the examination.

3. Test Result and Discussion

3.1. Tensile Test Result

From the load and elongation values obtained from the universal testing machine, corresponding engineering stress and engineering strain were calculated and plotted to get stress vs. strain curves for different samples of Al-5%SiC, Al-7%SiC and Al-9%SiC composition.

Table 1: Tensile Strength of Al-Sic Composite

S./N	Al-5%Sic	Al-7%Sic	Al-9%Sic
1.	OD=10.05mm^2	OD=10.05mm^2	OD=10.00 mm^2
2.	Load=440 kg	Load=560 kg	Load=680 kg
3.	Area= 79.32 mm^2	Area= 79.32mm^2	Area=78.53 mm^2
4.	Tensile Strength=54.35 (N/mm^2)	Tensile Strength=69.17 (N/mm^2)	Tensile Strength=84.94 (N/mm^2)
5.	Elongation = 6%	Elongation = 4%	Elongation = 2%

The ultimate tensile strength and yield strength increases with the increase of weight percentage of silicon carbide. It is observed that the total elongation decrease with the increase weight percentage of silicon carbide. The curves are continuous when transition is from elastic to plastic region. Therefore, the yield strengths of the alloys are computed by 0.2% offset method, according to ASTM standard.

3.2. Hardness Test Result

The result for specimens is shown in Table 2 the hardness value of cast composite increase as the weight percentage of SiC increases from 5%, 7%, and 9% in the composite. In this test load and ball diameter was constant for all specimens.

Table 2: Brinell Hardness Number

Composition	Indentation	BHN	Avg.BHN
Al + 5% SiC	4.39 4.38 4.37	31.4 31.5 31.7	31.5
Al + 7% SiC	4.11 4.10 4.09	36.4 36.2 36.0	36.2
Al + 9% SiC	3.99 4.00 4.01	38.3 38.1 37.9	38.1

It is observed that the Brinell hardness numbers for Al-5% SiC, Al-7% SiC and Al-9% SiC are found to be 31.5, 36.2 and 38.1 respectively. This indicated that hardness of the Al-SiC composition increases with the increase in the weight percentage of silicon carbide. This may be due to the increment of silicon carbide amount, which is harder.

3.3. Microstructure Test Result

Al-5% SiC composite contained more-or-less rounded particles of aluminium and dark areas by silicon carbide. In this case, silicon has networked structure. Al-7% SiC composite showed the refinement of the eutectic silicon particles. The silicon has long rod like structure. Al-9%SiC composite indicated that the degree of refinement of the eutectic silicon increased as the silicon content of the alloy increased beyond the eutectic composition. In addition, presence of primary silicon was also observed in the Al-5% SiC, Al-7% SiC and Al-9%SiC composites, although the size and volume fraction of the primary silicon Carbide is more in Al-9% SiC, as compared to Al-7% Sic composite. Consistently, Al-7%SiC showed more silicon carbide than Al-5%SiC.

4. Conclusions

From the microstructure studies, Yield strength and Ultimate tensile strength increases with the increase of weight percentage of silicon carbide. Total elongation decreases with the increase of weight percentage of silicon carbide. Hardness of the Al-SiC composite increases with increase in the amount of silicon carbide.

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