

Mechanical Characterization of Al 6061-Zircon Particulate Composites

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Abstract - Today composite materials gained popularity in their improved properties over the traditional materials, like low density, good thermal resistance, better corrosion resistance and surface finish. The Aluminium based metal matrix composites have the wide applications in Automotive and defence industries due to some good properties like strength to weight ratio, more wear resistance. In the present work Al6061 Alloy taken as the matrix alloy and zircon as the reinforcement, stir casting method was chosen to develop this composite. The melt composites in the graphite crucible were stirred by the mechanical stirrer and immediately it was poured to the cast iron moulds. Different samples of 0,3,6,9, and 12% of zircon were produced. Casted Samples were machined to ASTM standards. The Properties like tensile strength, impact strength, Hardness and wear rate of the developed composites were investigated. For the 9% of reinforcement it has been observed a significant improvement in strength, hardness and reduction in the wear rate.

Key Words : Metal matrix composites, Stir Casting, Al 6061, Zircon, SEM

1. INTRODUCTION

Particulate reinforced Aluminium metal matrix composite materials which are having desirable properties such as high specific stiffness, high specific strength, high coefficient of thermal expansion, increased fatigue resistance, superior dimensional stability compared to unreinforced alloys at the elevated temperatures. These properties of MMC's enhance their research in automotive and tribological applications. In the field of automobile MMC's are used for Piston's, brake drum and cylindrical block because of better corrosion resistance & wear resistance [1]

Al6061 is an aluminium alloy, with copper and magnesium as the alloying elements. It is used in applications requiring high strength to weight ratio, as well as good fatigue resistance. It is not weldable, and has average machinability[2]. Al6061 aluminium alloy is a precipitation hardening aluminum alloy, containing magnesium and silicon as its major alloying elements. It has good mechanical properties and exhibits good weldability. It is one of the most common alloys of aluminium for general purpose use. Al6061 is commonly used for the construction of aircraft structures, such as wings and fuselages, more commonly in homebuilt aircraft than commercial or military aircraft[3-6]. 2024 alloy is somewhat

stronger, but Al6061 is more easily worked and remains resistant to corrosion even when the surface is abraded, which is not in the case for 2024, which is usually used with a thin Aluminium clad coating for corrosion resistance, construction, including small utility boats. Automotive parts, such as wheel spacers, the manufacture of aluminium cans for the packaging of foodstuffs and beverages[7-9].

Zirconium silicate ($ZrSiO_4$) occurs in nature as mineral zircon. Ore is mined from natural deposits and concentrated by various techniques. It is separated from sand by electrostatic and electromagnetic methods. Also, the compound can be made by fusion of SiO_2 and ZrO_2 in an arc furnace, or by reacting a zirconium salt with sodium silicate[1] in an aqueous solution.[10].

1.1 Aluminium as matrix

Aluminium matrix composites have been used from many years in sporting goods, automotive sectors. The Aluminium alloy is having less density, high strength, and high damping capacity.

1.2 Zircon as a Reinforcement

Zirconium silicate is used for manufacturing refractory materials for applications where resistance to corrosion by alkali materials is required. It is also used in production of some ceramics, enamels, and ceramic glazes. Another use of zirconium silicate is as beads for milling and grinding.

2. Experimental

2.1 Materials

In the current work of aluminium matrix composites AA6061 As a matrix material and Zircon particulates with a size of 60microns as a reinforcement material.

Table1.Chemical composition of AA6061 Matrix material(wt%)

Al	Mg	Si	Fe	Cu	Zn	Ti	Mn	Cr
Balance	0.9	0.5	0.5	0.3	0.2	0.1	0.1	0.25

2.2 Development of composites

The Al6061 used in the form of ingots. The cleaned metal ingots were melted to the desired temperature of 700 °C in graphite crucibles. The Zirconium Silicate Particles of Size 65µm were introduced into the vortex of the molten alloy after degassing using Solid Hexachloroethane (C₂Cl₆). Before introducing reinforcement particles into the melt they were preheated to a temperature of 300° to remove the moisture in it. At every stage of before and after introduction of reinforcement particles, mechanical stirring of the molten alloy was carried out for a period of 10 minutes. The stirrer was preheated before immersing into the melt and run at a speed of 200 rpm. A Pouring temperature of 800 °C was adopted and the molten composite was poured into permanent cast moulds and allowed it for solidification. The same procedure was followed to obtain metal matrix composites of different weight percentages of reinforcement - 6, 9 and 12 % in the form of Cylinders of diameter 20mm and length 125mm.



Figure 1.(a) Experimental set up (b)Aluminium Ingots



(c) Zircon powder

(d) Casted component

Al6061	Zirconium Silicate	
Grams	Grams	Peercentage of Reinforcement
1000	0	0
970	30	3
940	60	6
910	90	9
880	120	12

Table 2.For Processing of Al6061-Zircon Composite Specimens

2.1 Specimen preparation

Castings were taken out from the mould and are machined in a conventional lathe to get the samples to ASTM standards for testing Tensile strength, Hardness and wear rate.

3. Results and Discussions

3.1 Microstructure

The microstructure of Al6061-Zircon particulate composites shows a uniform distribution of zircon particles in the aluminium matrix which ensures that a very good bonding between matrix and reinforcement.

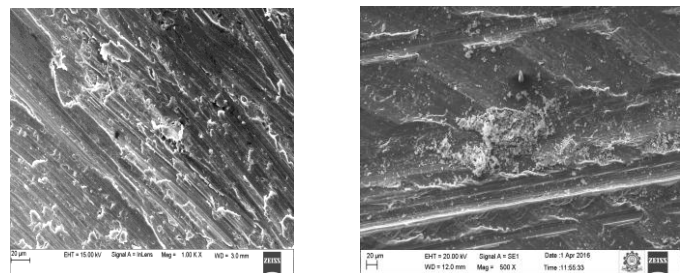
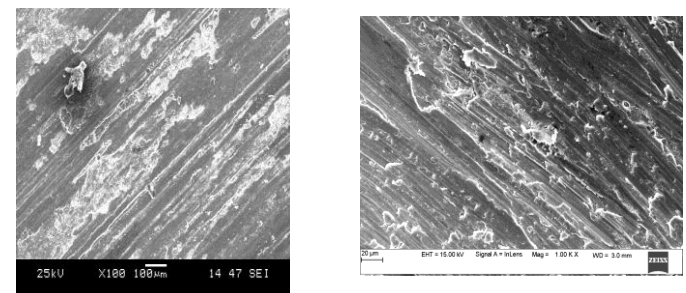


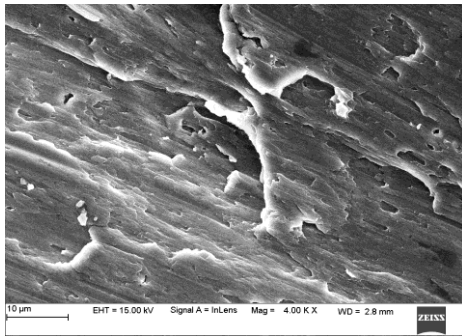
Figure 2.(a) Al6061+0%Zircon

(b) Al 6061+6%Zircon



(c) Al 6061+3%Zircon

(d) Al 6061+9%Zircon



(e) Al 6061+9%Zircon



Figure 4. Pin on Disc apparatus

3.1 Tensile strength

The below sketch indicates the tensile strength values of the developed composites. It can be observed that tensile strength values keeps on increasing trend with the addition of zircon particulates. However declining of tensile strength was observed for the developed composite because of agglomeration and casting defect. The increase in the tensile strength was observed from 70.72N/mm² to 142.39N/mm².

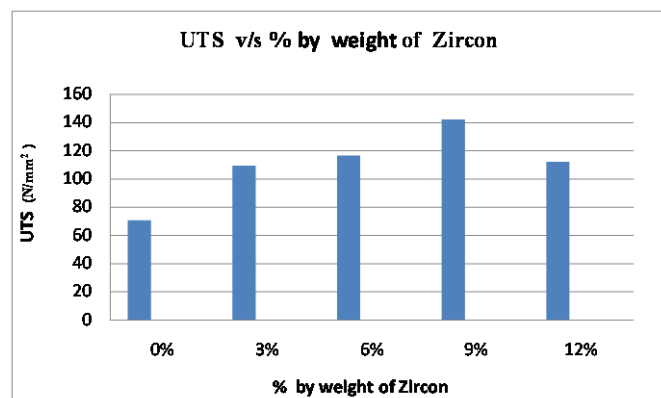


Figure 3. Variation of percentage of reinforcement versus Tensile strength.

3.2 Wear Study

Wear is a process of removal of material from one or both of two solid surfaces in solid state contact. Sliding wear tests as shown in Figure were conducted in pin-on-disc wear testing apparatus (model: Wear & Friction

Monitor TR-20, supplied by DUCOM as per ASTM:G99-05) under normal load, sliding distance, and speed. The surface of the specimen was rubbed against a hardened steel disc, which has a better surface finish. The test uses specimens of diameter 6mm and length 30mm machined from the cast specimens. The wear tests were conducted at a load of 1kg and speed 600 RPM. The test period was taken to be 5 minutes.

Table 3 Wear rate variation

% of Zircon	Wear Rate
0	0.6254
3	0.4378
6	0.3245
9	0.01134
12	0.24377

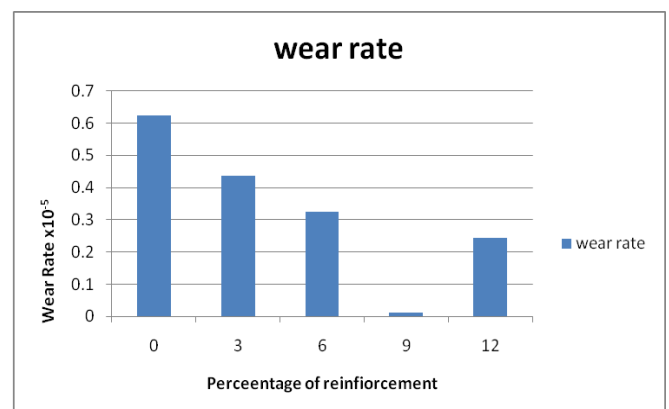


Figure 5 Graph of wear rate versus percentage of reinforcement. The graph plotted for 200RPM with sliding distance of 923.62m/min carried out for 10minutes under the load of 9.81N.

3.3 Hardness test

Hardness test has been conducted on each specimen using a load of 500 kg and a steel ball indenter of diameter 10 mm as indenter. The diameter of the impression made by indenter has been measured by Tool maker microscope. The corresponding values of hardness (BHN) were calculated from the standard formula. In the Brinell hardness test, a hardened steel ball indenter is forced into the surface of the metal to be tested. The diameter of the hardened steel indenter is 10mm. The standard loads are maintained as a constant for 10-15 seconds.

Figure 6 Brinhel Hardness Tester



% of Zircon	BHN
0	38.489
3	40.235
6	49.62
9	60.389
12	51.23

Table 4.Hardness number for the percentage of reinforcement

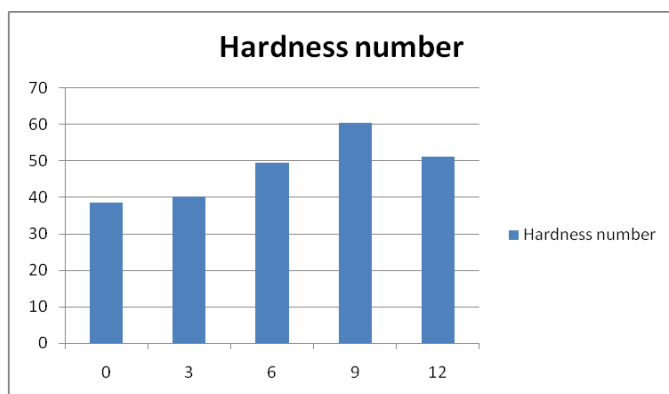


Figure 7 Graph of Hardness v/s percentage of reinforcement

The above graph shows that the increase in weight fraction of zircon ($ZrSiO_4$) particles in Al6061 matrix. The presence of such hard surface area of particles offers more resistance to plastic deformation which leads to increase in the hardness of MMC's. The hardness of specimen increases with increase in weight fraction of $ZrSiO_4$ and reaches a maximum value of 60 BHN for specimen Al6061+ 9% $ZrSiO_4$ and thereafter it decreases for 12% of reinforcement.

3. CONCLUSIONS

The significant conclusions of studies on Al6061-ZirconMMC'S are as follows.

1.Stir casting was adapted to manufacture Al6061-zircon COMPOSITES.

2.The wear properties are improved by the addition of zircon particulates

3.Mechanical properties like Tensile strength, Hardness, Impact strength increases with addition of reinforcement

4. Good observation of particle distribution made at 9% of reinforcement addition which gives greater bonding with the base metal.

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