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STUDY OF EFFECT OF COCONUT SHELL ASH (CSA) SECONDARY REINFORCEMENT ON ALUMINIUM SILICON CARBIDE COMPOSITE

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Abstract— Metal Matrix Composites (MMCs) have induced a keen interest in recent times for probable applications in aerospace and automotive industries due to their higher strength to weight ratio and high temperature resistance. In this respect Aluminium matrix composites are widely used in various advance industries like aerospace, defense, transportation, marine, automobile and sports, due to their better corrosion resistance, good mechanical property and high strength to weight ratio. The aim of the study is to fabricate a metal matrix composite material that consists of an agro waste like coconut shell ash (CSA) as secondary reinforcement with Al-6061 and silicon carbide using stir casting technique. The influence of the secondary reinforcement is studied by varying its percentage in the composite and testing it for wear, hardness, tensile properties and microstructure.

Keywords— Composite, Coconut shell ash, Al- 6061, Silicon carbide, Wear, Hardness, Tensile, Microstructure.

I. INTRODUCTION

ALUMINIUM 6061:

The aluminium alloy used in our project work is AA 6061, which has major composition of magnesium and silica. Alloys in the 6*xxx* series contain silicon and magnesium approximately in the proportions required for formation of magnesium silicide (Mg2Si), thus making them heat treatable. Although not as strong as most 2*xxx* and 7*xxx* alloys, 6*xxx* series alloys have good formabilityweld ability, machinability, and corrosion resistance, with medium strength. Aluminium 6061 has good formability, weld ability, corrosion resistance, and strength in the T-tempers. Good general-purpose alloy used for a broad range of structural applications and welded assemblies including truck components, railroad cars, pipelines, marine applications, furniture, agricultural applications, aircrafts, architectural applications, automotive parts, building products, chemical equipment, dump bodies, electrical and electronic applications, fasteners, fence wire, fan blades, general sheet metal, highway signs, hospital and medical equipment, kitchen equipment, machine parts, ordnance, recreation equipment, recreation vehicles, and storage tanks.

SILICON CARBIDE:

Silicon Carbide is made by combining silicon and carbon, its chemical formula is SiC, also known as carborundum. Grains of silicon carbide can be bonded together by sintering to form very hard ceramics that are widely used in applications requiring high endurance, such as car brakes, car clutches and ceramic plates in bullet proof vests.

COCONUT SHELL ASH:

Coconut Shell Ash (CSA) is one of the low-cost, solid waste materials, available in large in large quantities throughout the tropical countries. The coconut is thoroughly washed with water to remove dust and dried at room temperature for 1day. After crushing and extraction of shell from coconut, the coconut shell is formed in powder form. The grounded powder was packed in a crucible and fired in an electric furnace at a temperature of 1300°C to form coconut shell ash. It improves the mechanical and tribological properties of MMC's.

Table.1 Composition of CSA

Element	SiO	MgO	Al_2O	Fe_2O	MnO	ZnO	Na_2O	K_2O
%	46	18	16	14	0.5	0.6	0.9	1.2

Fig.1 Burning of coconut shell

ROCKWELL HARDNESS TEST:

Rockwell hardness of a material involves application of a minor load followed by major load. The minor load resets to zeroth position. Major load is applied, then removed while maintaining minor load. Depth of penetration from the zero position datum is measured on a dial, on which a harder surface gives a much higher hardness number. The depth of penetration decreases as hardness increases and vice versa. The advantage of Rockwell hardness is that it displays the hardness values directly. To get an appropriate reading the thickness of the work piece should be at least 10 times depth of the indentation. Readings should be taken on a flat surface, as convex surfaces gives lower readings. A correction factor is used if the hardness of a convex surface is measured.

WEAR ANALYSIS (PIN-ON-DISC):

In a pin-on-disc wear tester, a pin is loaded on a flat rotating disc specimen in such a way that the circular wear path described by the machine is followed. The machine is used to evaluate various wear and friction properties for different materials under pure sliding criteria. Either disc or pin can act as specimen, while the other acts as a counter face.

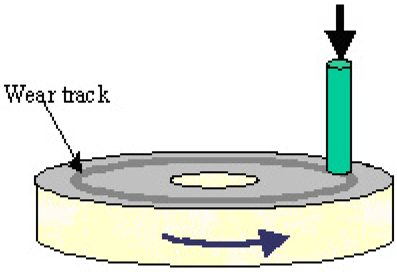


Fig.2 Pin on Disc

TENSILE TEST:

This is also known as tension test, it is a fundamental material science test in which a sample is subject to controlled tension until failure, it has maximum elongation and reduction in area. Properties that are directly measured via tensile test are ultimate tensile strength.

Samples were machined and tested as per ASTM E8 standard. Bench tensometer was the device used to test the tensile strength. The electronic Tensometer is a compact and bench model horizontal Tensile Testing Machine of capacity 20 KN. It is a small version of UTM- Universal Testing Machine and is used for testing tension and also compression, shear and flexural properties of different materials. PC 2000 model tops in the series of Tensometer and was used to test the tension.

Table.2 Specimen compositions

Specimen	Aluminium 6061 (wt kg)	Silicon Carbide (% by wt)	Coconut Shell Ash (% by wt)
Specimen 1	1kg	0%	0%
Specimen 2	1kg	5%	3%
Specimen 3	1kg	10%	6%
Specimen 4	1kg	15%	9%

II. EXPERIMENTAL METHOD

WEAR ANALYSIS:

Apparatus: Pin-on-disk wear testing machine, weights, spanner, acetone, cotton and specimen pins.

Procedure:

1) Remove any debris by cleaning the disk with acetone.
2) Existing loads must be removed.
3) Specimen is weighed.
4) Specimen is fixed to the pin holder.
5) Loads are applied.
6) Power source is switched on and timer is set for 5 minutes with a speed of 500 RPM.
7) Take down the final weight of the specimen after conducting the wear test.
8) Repeat the experiment under different loading condition say 1kg, 2kg, 3kg etc.
9) Tabulate the results and the plot the graphs.

TENSILE TEST:

Apparatus: Machined specimens according to the dimensions, Bench Tensometer

Procedure:

1. Machine the specimens as per the device compatibility.
2. Suitable pair of shackles is selected to fix the shoulder.
3. Specifications of the specimen mainly gauge length and its outer diameter was entered and accordingly percentage elongation was set.
4. The sample was laid in the cradle before stretching it and the pivoted arm was moved to the right slide before the arm reading is zero.
5. The right slide is locked and test was conducted.
6. The test graph is displayed online and thus instantaneous results are obtained.

HARDNESS TEST:

Apparatus: brinell hardness testing machine, Hand microscope.

Procedure:

1. Select the suitable indenter and weights according to the scale.
2. Place the specimen on the testing table anvil.
3. Turn the hand wheel to raise a job until it makes contact with indenter and continue turning till the longer point at the dial gauge makes 2.5 rotations. Then it stops at zero, continue turning slowly till the small pointer reaches the red spot 3.This is automatic zero setting dial gauge.
4. Turn the lever from unloading to loading position so that total load will set.
5. When the longer position pointer of the dial gauge reaches steady position, take back the lever to the unloading position.
6. Remove the job from the platform and note down the diameter of the indentation using microscope.
7. Use appropriate formula, calculate BHN and similarly repeat for different specimens.

III. EXPERIMENTAL RESULTS AND DISCUSSION

WEAR TEST:

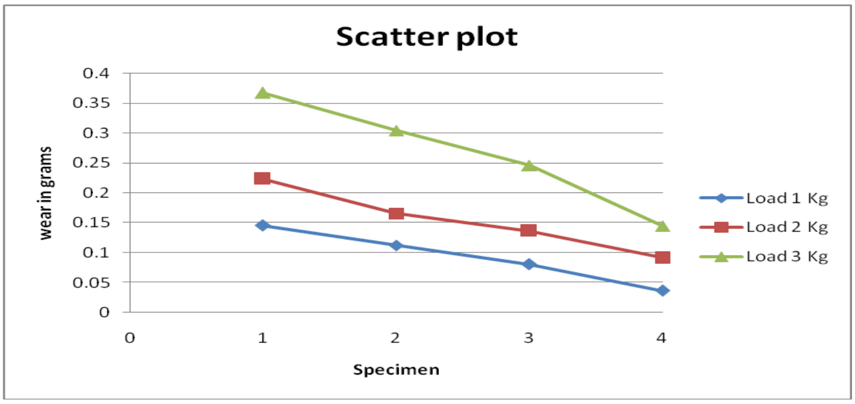


Fig.3 Scatter Plot for Wear

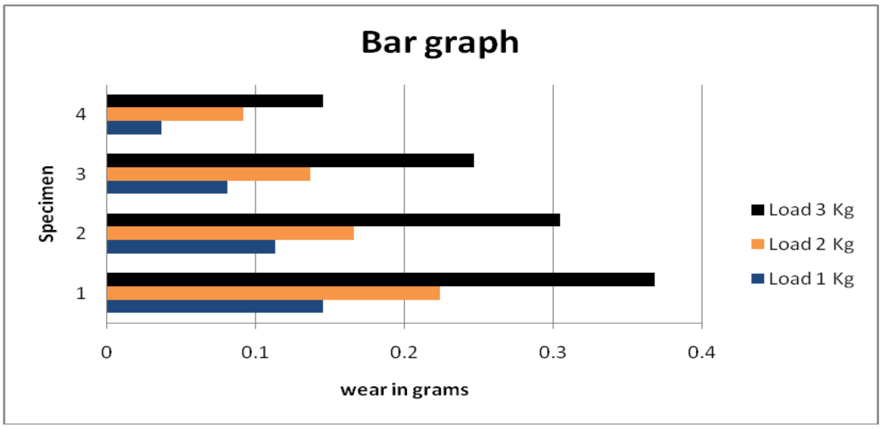


Fig.4 Bar Plot for Wear

TENSILE TEST:

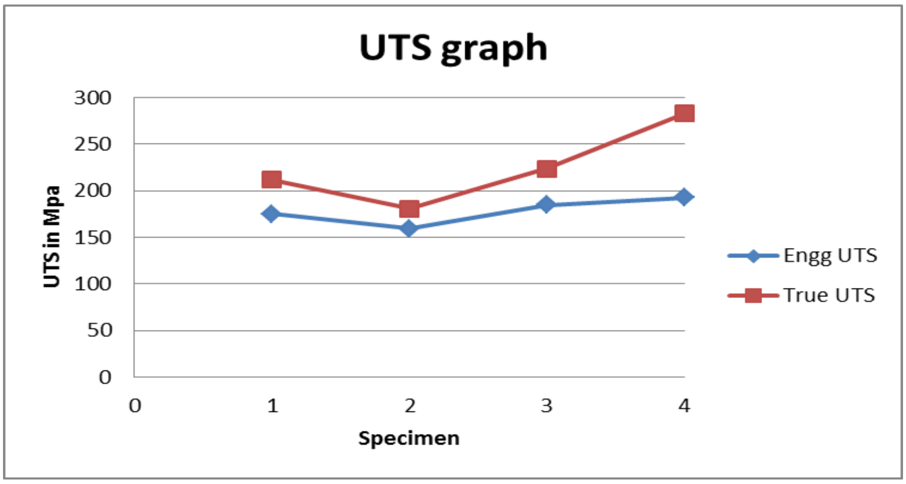


Fig.5 Graph of Ultimate tensile Strength

Sl.no	PARAMETERS	SPECIMENS			
		1	2	3	4
1	Initial area, mm^2	31.68	31.68	31.68	31.68
2	Initial gauge length, mm	26	26	26	26
3	Peak load, N	5550.8	5060.4	5848.8	6109.8
4	Engineering Ultimate Tensile strength, MPa	175.2	159.7	184.8	192.8
5	True Ultimate Tensile strength, MPa	211.9	181.00	223.8	283.1

Table 3 Tensile test results

HARDNESS TEST:

Table 4 Hardness values

Sl.No	Specimen %	APPLIED LOAD (Kg)	BRINELL HARDNESSNO. (BHN)
1.	Al-6061+0%SiC+0%CSA	100	47.79
2.	Al-6061+5%SiC+3%CSA	100	59.29
3.	Al-6061+10%SiC+6%CSA	100	73.15
4.	Al-6061+15%SiC+9%CSA	100	37.55

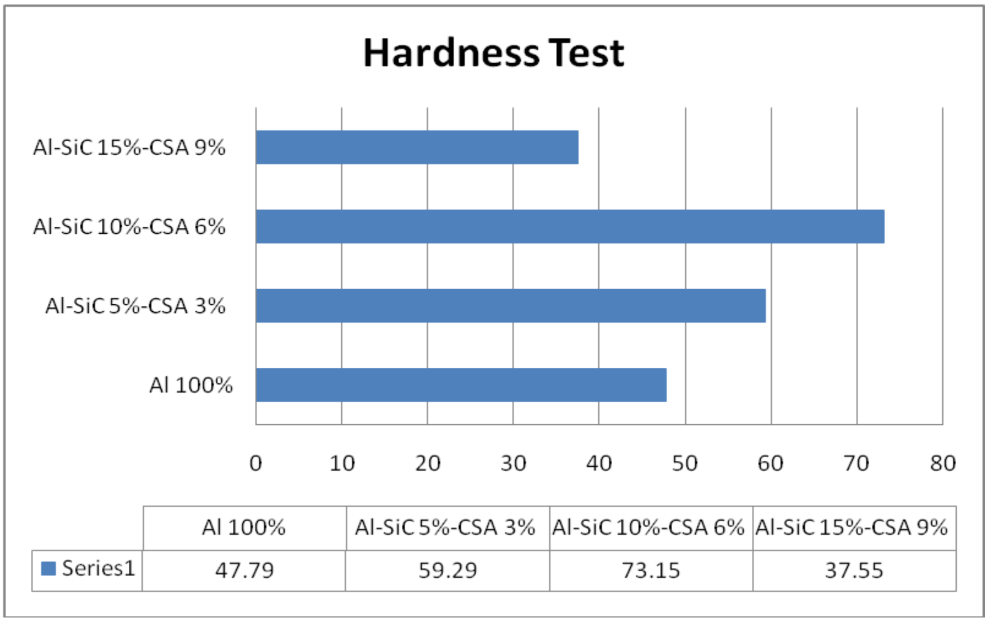
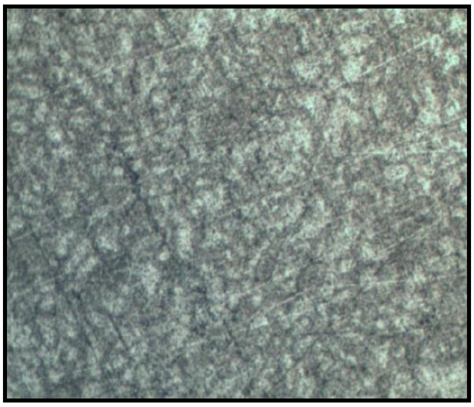


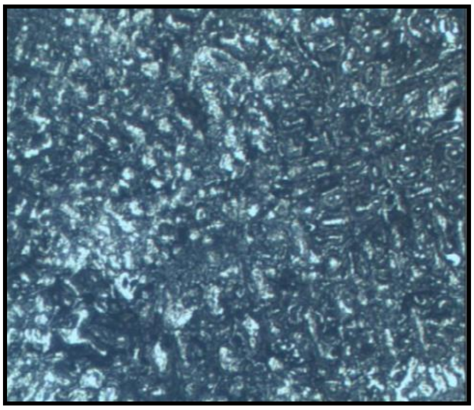
Fig.6: Hardness test graph

MICROSTRUCTURE EXAMINATION:

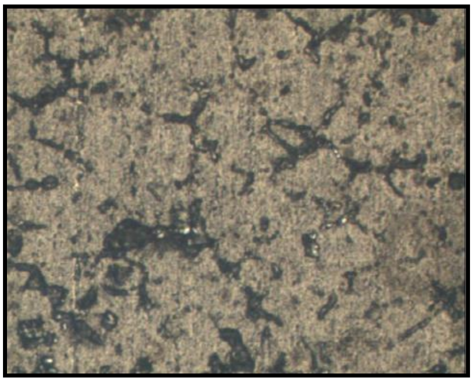
The microstructure observations of the casted specimens are as shown below. The microstructures show the distribution of Silicon Carbide and CSA particles.
The samples are roughened with belt polish and fine polished with various emery papers from 80,120,400, 600 and fine polished using Alumina and structures are observed. The microstructure examination showed that the reinforcements were dispersed in the alloy. The grain boundaries are visible and no porosity is seen.



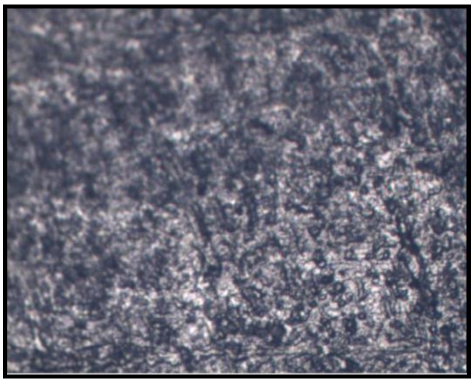
SPECIMEN 1



SPECIMEN 2



SPECIMEN 3



SPECIMEN 4

IV. CONCLUSIONS

The presence of particles like SiO, MgO, MnO, Al_2O_3 etc in the ash which are clearly oxide based or ceramic based gets dispersed with the aluminium matrix and binds the particles with the matrix material. When the tensile test is being conducted, the pulling force or load when applied on the specimen gets transferred from the matrix and hence will be taken upon by the reinforcing particles. These reinforcing particles aid the matrix material to resist any sort of deformation up to the yield point. Even though these reinforced particles takes up majority of the load during loading, it is nevertheless a ceramic particle, which means that post yielding the composites may not show any necking and will lead to sudden failure.There is an increase in the ultimate tensile strength of the composites and specimen 4 (15% SiC and 9% CSA) has the highest UTS value.

From the composition of CSA particles it can be certainly perceived that it contains major amount of SiO in it which is a very hard ceramic particle of its own accord. When these CSA particles are used as reinforcement material in Al metal, the hardness is ought to increase due to the presence of hardening elements like SiO, MgO, MnO in reinforced ash as there is a uniform distribution of particles in the matrix of Aluminium.

The hardness values increased compared to the pure alloy without reinforcement and specimen 3(10 % SiC and 6% CSA) was found to have the highest hardness number.

The reinforced composites were found to have less wear loss compared to the base alloy.

Microstructure evaluation showed dispersion of the reinforcements in the specimens.

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