Flexural Strength Behavior of Al 6061matrix Reinforced with SiC and Coconut shell ash

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Abstract

In this study, Al6061 matrix reinforced with Silicon Carbide (SiC) and Coconut Shell Ash (CSA) prepared by double stage stir casting process were used to fabricate the Al6061 hybrid composite materials and their flexural, impact strength behavior was studied. The wt% of SiC is kept constant at 10% and the additional level of CSA is varying from 2-10% in steps of 2 wt%. An identification of crystalline materials was analyzed by X-ray diffraction (XRD) technique. The flexural strength is increases maximum at 6wt% of CSA compare with unreinforced Al6061 by 49% of improvement; also this result showed that the Al6061 hybrid composites have better properties than Al6061 base alloy. The impact strength of Al6061-SiC composite with 6% CSA exhibited high impact resistance than the unreinforced Al6061.

Keywords: Al6061, CSA, Stir casting, flexural strength.

I. INTRODUCTION

A composite material is a macroscopic combination of two or more distinct materials, having a recognizable interface between them; Composite materials are used structural, electrical and automobile component etc., [1]. By using liquid state process for making hybrid composites proper stir casting parameters help to improve the tensile and hardness of composite material properties; also it produces homogeneous distribution with minimum porosity of ceramic reinforcements with Al 6061 by selecting proper stir casting parameters like stir speed, blade angle and stirring duration [2]. Various volume fraction and grit size of reinforcement gives different mechanical properties in composite materials. Inegbencbor et.al, investigated that at 7.5% Volume fraction of SiC particles influences the strength and mechanical properties of the composites [3]. Wear resistance and hardness strength is very low in unreinforced aluminium alloy. By adding ceramic reinforcements like SiC, B_4C, Al_2O_3, TiC, TiO_2, with aluminium is increases wear, hardness and tensile strength to the aluminium. Hariprasad et.al [4], reported that Al 5083with Al_2O_3 -B_4C8% has excellent wear resistance due to the presence hard ceramic particles at minimum level. Bharath Mahadev et.al [5] investigated that the increase in wt% of Al_2O_3 at 3% differences was successfully fabricated with Al6061 by stir casting process. They concluded that the hardness, wear and tensile strength of the composites increased upto 12%wt of Al_2O_3 compared to base metal, and ductility is decreased by increasing Al_2O_3 compared to base metal. Anil Kumar et.al.[6] studied that the mechanical properties is increased with increase in the weight fraction reinforced FA particles and ductility is decreased while increasing FA particles to the composites. Also increasing the mechanical properties upto 15%wt of FA with Al matrix further it decreases. Therefore, the objective of this study is to analyze the XRD images and investigate the flexural behavior, impact strength of Al6061 matrix hybrid composites reinforced with SiC and CSA.

II. MATERIALS AND METHODS

Al 6061 material was used on base metal making hybrid composite materials. Silicon carbide (SiC) of mesh size of 220, coconut shell ash average particle sizes are 1microns was selected as reinforcing materials. The coconut shell was collected, dried in sunlight for two days to remove moisture content. Then dried coconut shell were ground to powder form and placed in graphite crucible burned thoroughly till the powder gets complete combustion. The chemical composition of CSA was analyzed by XRF (CECRI-Karaikudi) and the values are show in table.1.

Table.1 Chemical Composition of CSA

Elements	Mass %
SiO_2	65.87
Al_2O_3	4.78
Fe_2O_3	14.22
CaO	5.77
K_2O	8.99
TiO_2	0.32

A. *Experimental procedure*

The mixture of SiC and CSA particles were used as the reinforcement material. Five different weight percent of CSA (2 %, 4 %, 6%, 8% and 10 %) and fixed weight percent of SiC (10 %) were used in this study. 1 wt.% of magnesium powder was used as a wetting agent for improving fluidity of melted composites. Initially, calculated amount of the Al 6061alloy was charged into the graphite crucible and heated up to 750°C for completely melting of the alloy. The heating rate is 5 to 6°C/min is maintained for heating purpose. Preheat the SiC and CSA reinforcement particles at 500°C for 30 min to remove moisture content and reduce the particle sizes drastically its improve the strength of the composites.

Fig.1. Stir casting setup

Here, two stage stirring method [7] were used to disperse the SiC and CSA particles in the aluminium matrix alloy, because of CSA particles has low density (1.65 g/cc) and it floats above the top layer of aluminium metals after feeding. The first stage of the stirring was carried out when the slurry was in a semi-solid condition and the second stage when the slurry was remelted and adding preheated reinforcement particles at constant feed rate to the matrix at a temperature of 750°C. The stirring time was maintained for 4 minutes. After stirring the molten mixture it was poured in to mould of dimension 100 x100x10mm size preheated die.

B. X-Ray Diffraction Analysis

The composites prepared were analysed with the help of x-ray diffraction technique to check the presence of different compounds in the Al6061 hybrid composites.

C. Flexural Strength

The behavior of material subjected to simple bending load was measured by the flexural test. The specimen was prepared as per ASTM A: 370 standards [8] with the dimensions of 100 x10x10 mm square rod were used. The flexural strength (σ) of any composite specimen is determined by using equation (1)

$$\sigma = \frac{3PL}{2bt^2} \text{ ------------- (1)}$$

Where

Σ is the flexural strength in N/mm^2 or MPa
L is the span length of the sample (mm).
P is the load applied (N)
b and t are the width and thickness of the specimen (mm)

D. Impact test

The amount of energy absorbed by the specimen when subjected to sudden dynamic load was measured using an impact test. The specimen was prepared as per IS: 1757 standards as shown in Fig. 2. In this work, the Charpy impact test was used.

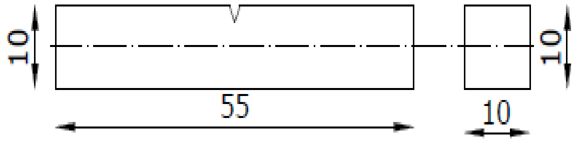

Fig.2 Impact Test Specimen

III. RESULT AND DISCUSSION

A. X-Ray diffraction analysis

The crystalline particles presents in hybrid composites were investigated by X-ray diffraction (XRD). The XRD technique is used and the presence of Al and SiO_2 was found as shown in Figure 3. The predominant peaks of Al are 38.4, 44.71, 65.1 and 78.2° (JCPDS No. 89-4037) shows good dispersion of Al6061 matrix throughout the composites which indicates the strength of the hybrid composites will be increases and SiO_2 observed at 38.45° which is in good agreement with the JCPDS data 00-001-0649. SiC peaks observed at 36.2° from Al6061-SiC composite to hybrid composites (JCPDS.No 74-1302). There is no minor peaks are visible and it was concluded that the there is no impurities presents in Al6061 hybrid composites. Other peaks are not visible due to the wt% of Al_2O_3 and Fe_2O_3 are less than 5% by the total wt% of hybrid composites

B. Flexural Test

It was the 3-point bending method to study the behavior and ability of the material under bending load. The load was gradually applied from the top roller until the deformation was observed.

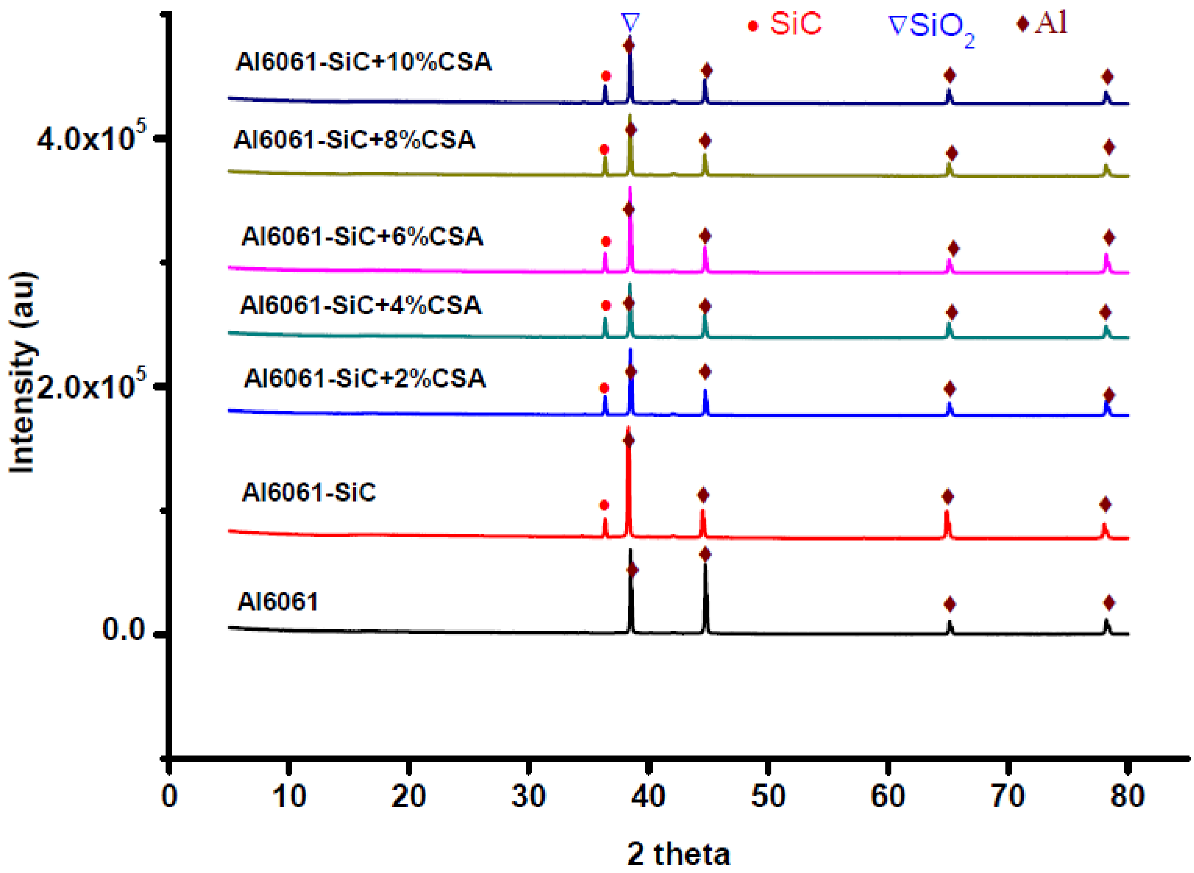

Fig 3. XRD peaks of Al6061 hybrid composites

Table. 2 Flexural and impact strength of Al6061 hybrid composites

Sample Composition	Flexural Strength (MPa)	Impact strength N.m
Al 6061	299.71	2
Al 6061+ 10% SiC	373.09	2.2
Al 6061+ 10% SiC + 2% CSA	390.63	2.7
Al 6061+ 10% SiC + 4% CSA	433.55	3.1
Al 6061+ 10% SiC + 6% CSA	446.29	3.2
Al 6061+ 10% SiC + 8% CSA	409.23	2.9
Al 6061+ 10% SiC + 10% CSA	395.27	2.2

Flexural strength is the 3-point bending method to study the behavior and ability of the material under bending load as per ASTM A: 370 standards [8]. The value of flexural strength was obtained from three point bending test as shown in table.1. It reveals that the flexural strength was calculated from flexural load and the strength is increases with increasing reinforcement content up to the sample 6% CSA is by 48.9%. After that the strength is decreases due to more additions of CSA in the matrix.

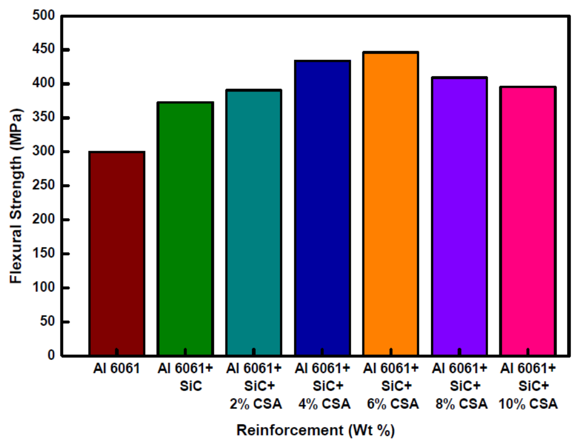

Fig.4. Flexural Strength of Al6061 hybrid composites

Figure 4 shows the effect of the weight fraction of reinforcement on the flexural strength. The flexural strength of Al6061 is about 299 MPa and this value increases to a maximum percentage of 446 MPa for Sample 6%wt of CSA hybrid composites which is about 49% improvement on that of Al6061 base metal. After that, additions of CSA to Al6061-SiC composite it decreases the flexural strength. In the 10wt% SiC with 8 wt% CSA hybrid composite the strength fell down slightly to 409 MPa compared to 6wt% of CSA hybrid composites which is about 9% decrement due to the decreasing the ductility of hybrid composites.

C. Impact test

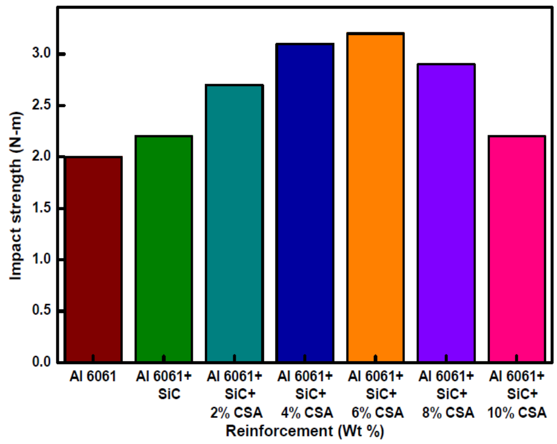

Fig 5. Impact Strength of Al6061 hybrid composites

Impact test result shows that the energy required breaking the specimen and it is varying from base alloy to hybrid composites. Initially 2.2 N.m was observed in Al6061-SiC composite. In the addition of 2 wt% (in steps 2%) CSA in to Al6061-SiC composite the impact energy is increases by 2.7, 3.1, and 3.2 N.m further it decreases by, 2.9 and 2.2 respectively. Addition of CSA upto 6 wt% the material absorb shock load upto 3.2 N.m. after that it decreases due to the too much crystalline materials were added into the Al6061-SiC composite. It reduces the ductility of the Al6061 hybrid composites.

IV. CONCLUSION

The results are obtained by testing the various specimens are listed below and are follows: Stir casting method can be successfully used to manufacture Al6061-SiC-CSA matrix hybrid composites with desired properties. An XRD peak shows the uniform distribution of Al matrix in cast specimen and it confirms with JCPDS data. The flexural strength (bending strength) of hybrid composites material increases (49%) by increasing the wt% of CSA reinforcement upto 6% further, it decreases the strength Al6061-SiC composite. More crystalline materials cause brittleness so as to reduce the impact strength of hybrid composites.

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