Fabrication and Characterization of Aluminium Composite Reinfoced with Silicon Carbide And Areca Leaf Sheath Fiber Ash

Abhijith T S[1], Akhil M S[1], Akshay Mohan E[1], Amal C[1], Favas Iqbal[1],Pradeesh A R[*2]
[1]Student Department of Mechanical Engineering, Ammini College of Engineering, Palakkad, Kerala, India
abhijith.t.seth@gmail.com[1]
*[2]Asst.Professor Department of Mechanical Engineering, Ammini College of Engineering, Palakkad, Kerala, India
Pradeesh_ar@yahoo.co.in[*2]

ABSTRACT

Hybrid Aluminium Matrix Composites (HAMC) is of greater importance in the present industrial scenario due to its improved mechanical properties and low cost. In this study, HAMC having Aluminium (LM25) as matrix and silicon carbide (SiC), Areca Leafsheath Fiber Ash (ALFA) as reinforcements was fabricated using stir casting. 3%, 5%, 7% weight fractions of ALFA and 7%, 5%, 3%weight fractions of SiC respectively reinforced with the 90 % weight fraction of matrix to form three samples of different composition. Density measurement, estimated percentage porosity, tensile testing, impact testing, hardness testing, corrosion testing and Field Emission Scanning Electron Microscopy (FESEM) examination was used to characterize the samples. Results show that tensile strength of composite increases with decrease in ALFA content and elongation is least for 5% of each reinforcements.Hardness and impact energy remains same with different ALFA compositions.Density decreases with increase in ALFA content. FESEM result shows agglomerated reinforcements in compositions except insample with 5% SiC and 5% ALFA. For composition with 5% sic and 5%ALFA shows uniform distribution. Good corrosion resistance of Aluminium was reflected on the samples.

Keywords : Hybrid Composite, stir casting, Areca Leaf Sheath Fibre Ash,SiC

I. INTRODUCTION

For the past thirty years, fabrication and characterization of Aluminium based composites was of greater importance in the area of material science and engineering. This is because of the better mechanical and micro structural properties shown by Aluminium composites. Applications of Aluminium composites are of wide range including automobile components, aerospace, defense, and other important industrial applications to the development of sports and recreation facilities, the area of application is still growing. This is due to the higher performance and low cost of production of AMCs in comparison with other competing engineering materials for similar applications. The properties of the composite are greatly determined by the selection of reinforcing materials. Using industrial and agro wastes as reinforcing materials along with costly synthetic reinforcements like silicon carbide and alumina helps to reduce cost of production of composites. Graphite, fly ash and silica are some examples for industrial wastes used as reinforcements. Bamboo leaf ash, rice husk ash, bagasse ash, coconut shell ash are certain agro wastes used as reinforcements in AMCs. In this research work, Aluminium matrix hybrid composites using areca leaf sheath fiber ash and silicon carbide as complementing reinforcements are fabricated and characterized. Areca leaf sheath is a greatly available agro waste in south India which is not being efficiently used. In this paper, the fabrication, micro structural features, mechanical and corrosion behaviour of an aluminium matrix composite reinforced with varied weight ratios of areca leaf sheath fiber ash and silicon carbide is reported.

II. METHODS AND MATERIAL

A. MATERIALS

Investigation is carried out on composite with Aluminium LM25 grade as matrix which was purchased in form of bar. Chemical composition of LM25 is depicted on Table.1.Black SiC in powder form of 320-grit size and areca leaf sheath from south India is collected for reinforcing in composites.

TABLE I

Chemical composition of Aluminium LM25

Copper	0.1 max
Magnesium	0.2-0.6
Silicon	6.5-7.5
Iron	0.5 max
Manganese	0.3 max
Nickel	0.1 max
Zinc	0.1 max
Lead	0.1 max
Tin	0.05 max
Titanium	0.2 max
Lead	remainder

B. METHODS

1. PREPARATION OF ARECA LEAF SHEATH FIBER ASH

Areca leaf sheaths were collected from plantations and were soaked in water for 24 hours. Skins at both sides were peeled off from leafsheaths taken out from water. Fibres are extracted manually by hand extraction and fibres are dried under sunlight. Dried fibres are burned under excess air in a metallic container are left for complete combustion and ash is left for cooling.

2. PRODUCTION OF COMPOSITES

Stir casting was adopted for the preparation of composites. To determine the amount of ALFA and SiC required for preparing 10 weight % of reinforcements consisting of 3:7, 5:5 and 7:3 ALFA and SiC weight percentages respectively charge calculation was carried out. ALFA and SiC was initially preheated to 580 ^{0}C in SWAMEQUIP electric preheater. Aluminium LM25 was then heated to 756 ^{0}C in SWAMEQUIP electric furnace to liquid state, which is then cooled to semi-solid state at 550 ^{0}C on to which heated reinforcements were added by hand. Stirring is carried out at 550 RPM for 10 minutes after which molten metal composite is poured to prepared moulds.

3. TENSILE TEST

Tensile test is conducted on TUE-CN-400 UTM under ASTM E-08 standards. Casted composites were machined to round specimens with gauge length 35mm and specimen diameter 8.77 mm. Yield stress,tensile strength and elongation are the tensile properties evaluated from the stress-strain curve.

4. DENSITY AND POROSITY MEASUREMENT

Theoretical density and experimental density of various compositions of composites were determined. These densities are then compared to get the actual density of the composite. To determine the experimental density of the composite the measured mass of the sample and the measured volume of the sample is divided. The theoretical density was evaluated by using the rule of mixtures:

$$\rho_{th} = (\rho_{Al} \times W_{Al})+(\rho_{ALFA} \times W_{ALFA})+(\rho_{SiC}\times W_{SiC})$$

where $\rho_{th}$is the theoretical density of composite, $\rho_{Al}$is the density of Aluminium LM25 , W_{Al} is the weight fraction of Al, $\rho_{ALFA}$is the density of Areca leaf sheath fibre ash (which is calculated by pycnometer method under ASTM D854-14),
W_{ALFA} is the weight fraction of areca leaf sheath fibre ash, $\rho_{SiC}$is the density of SiC and W_{SiC} is the weight fraction of SiC.
Estimation of percentage porosity was evaluated using the relation:

$$\% \text{ porosity} = (\rho_m - \rho_{th}) / \rho_m$$

Where ρ_m is the measured density and ρ_{th} is the theoretical density of composites.

5. HARDNESS MEASUREMENT

Hardness testing of samples was carried out on MSM Rockwell hardness tester Under ASTM E18-16 standard. A load of 60 Kgf was applied on specimens with a 120^{0}diamond sphero-conical intender for 15 seconds. Hardness tests were carried out several times and average values were taken for each sample.

6. IMPACT ENERGY TEST

Impact energy was found by charpy impact test on AIT-300-EN under ASTM E08 standards. Pendulum hammer arm was fixed at 120^0 and dial was adjusted to 300J.Testing specimen has a dimension of 55×10×10mm and a V-notch is provided on the specimen. Impact energy, after test is obtained in Joules.

7. CORROSION BEHAVIOUR

Behaviours of composite samples were examined by conducting salt-mist spray test under ASTM B117 standards for 24 hours.

8. MICROSTRUCTURAL EXAMINATION

A Carl Zeiss microscope-UK&SIGMA- FESEM equipped with GEMINI column with its in-lens secondary electron detection and high vacuum mode of operation was utilized for microscopic investigation of composites produced. Samples with dimensions 10×10×10mm were inspected under microscope up to a magnification of 20,000 times for evaluating the microstructure.

III. RESULTS AND DISCUSSION

1. MICROSTRUCTURE

FE-SEM photographs of hybrid composites with different compositions of SiC and ALFA is depicted in Fig. 1.It is observed that reinforcements (SiC and ALFA) are visible around the matrix (LM25).Non-uniform distribution of matrix and reinforcements is seen in 5:5 % of both reinforcements and particle clusters are least formed (Fig.1 (b)).Fig.1 (a) is the FESEM photograph of sample with 3% SiC and 7% ALFA. From Fig.1 (a) agglomeration of reinforcements is clearly visible. Result obtained for sample with 3% SiC and 7% ALFA of reinforcements explains a uniform distribution of matrix and reinforcements which is clear from Fig.1 (c). Non uniform distribution and formation of clusters is due to manual addition of reinforcement particles while casting. Particle clusters were formed due to high surface tension and poor wetting between particles and the melt.

Table 2 represents percentage porosity of different samples. Comparisons of experimental and theoretical densities shows slight porosity for sample 3 but for samples 2 and 1 porositylevel is high .Thus, it may be concluded that SiC content have more bonding properties than ALFA as SiC content increases porosity of composites also decreases.

TABLE 2
DENSITY AND ESTIMATED POROSITY

Sample	Weight Ratio of SiC And ALFA	Theoretical density (g/cc)	Measured density (g/cc)	Porosity (%)
1	3:7	2.59	2.734	5.03
2	5:5	2.64	2.806	5.9
3	7:3	2.684	2.709	0.916

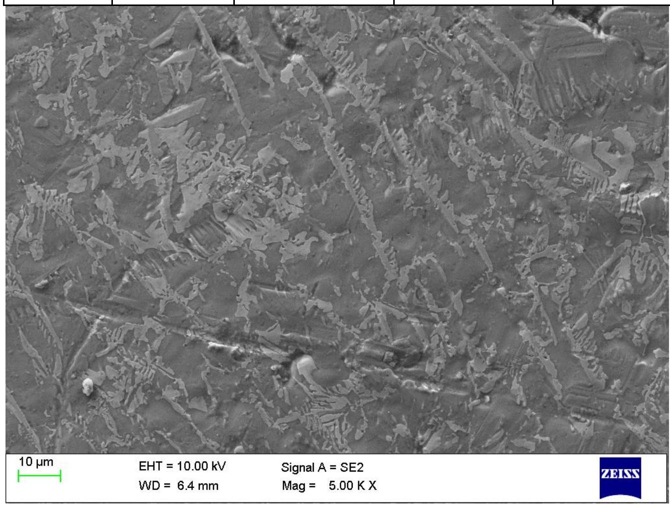

Fig.1 (a) FESEM photograph of sample with 3 % SiC and 7 %ALFA

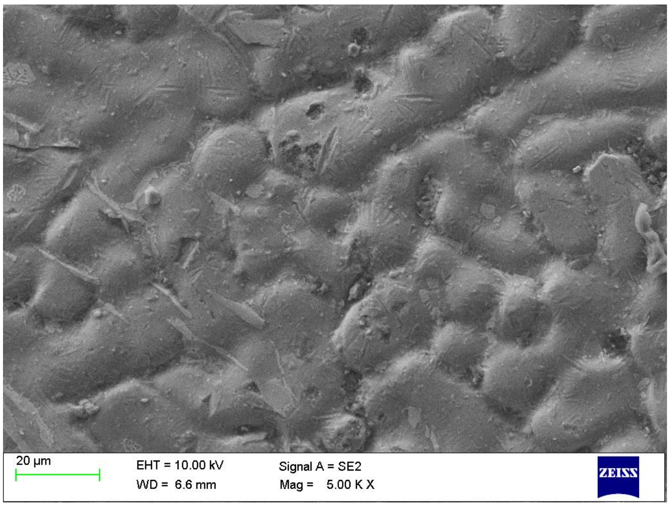

Fig.1 (b) FESEM photograph of sample with 5 % SiC and 5 %ALFA

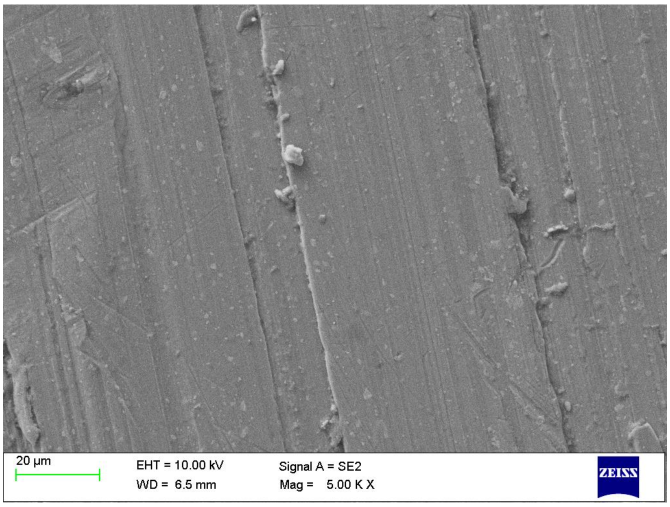

Fig.1 (c) FESEM photograph of sample with 7 % SiC and 3 %ALFA

2. MECHANICAL BEHAVIOUR

Variation of mechanical properties for different compositions of hybrid composites are depicted on figures 2-5.In Fig.2 variation of tensile strength of samples were compared.It is observed that tensile strength is greater for hybrid composite compared to that of aluminium (LM25).Reduction in tensile stress is observed with increase in ALFA content.Similar trend is seen in Fig.3 which describes the variation of yield stress.Increase in tensile strength for sample1, sample2 and sample 3 were 5.95 % ,8.72 % and 47.19 % respectively when compared with parent metal.4.16 % ,6.7 % and 36.42 % increase in yield stress of samples1,2 and 3 repectively when comparing with parent metal isobserved.Variation of elongation of different samples is shown in Fig.4.

Hardness value remains same for sample 1 and sample 3 but for sample 3 reduction in hardness is observed.Fig.5 depicts this result.Reduction in hardness of hybrid composite is seen when compared to parent metal.This is due to lower hardness level of ALFA in which SiO_2 is the major constituent.

Impact energy variations is represented in Fig.6.Impact energy remains same for all the three compositions and impact energy value is low.This is due to cluster formations in casting and prescence of porosity which propogates crack easily.

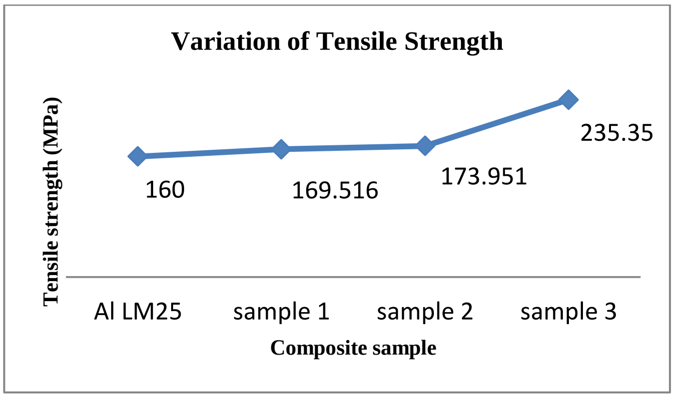

Fig.2.Variation of Tensile Strength

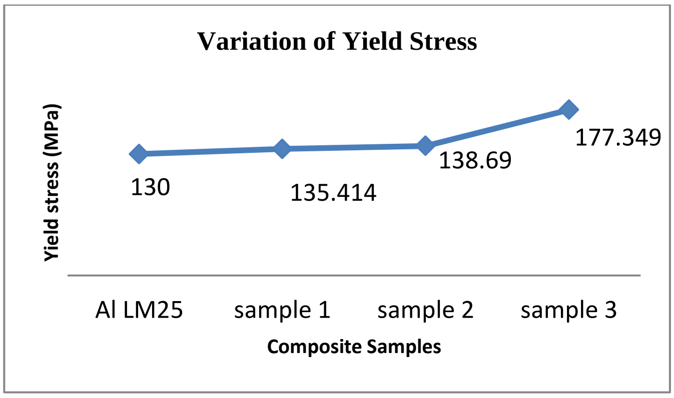

Fig.3.Variation of Yield Stress

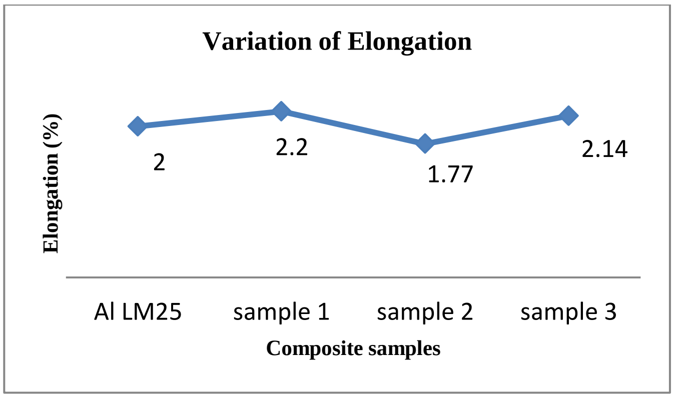

Fig.4.Variation of Elongation

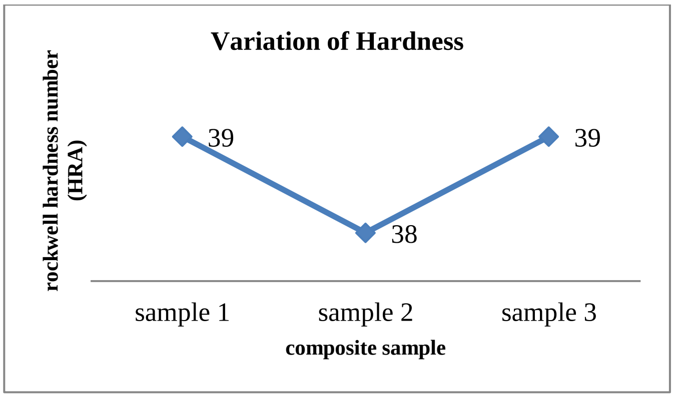

Fig.5.Variation of Hardness

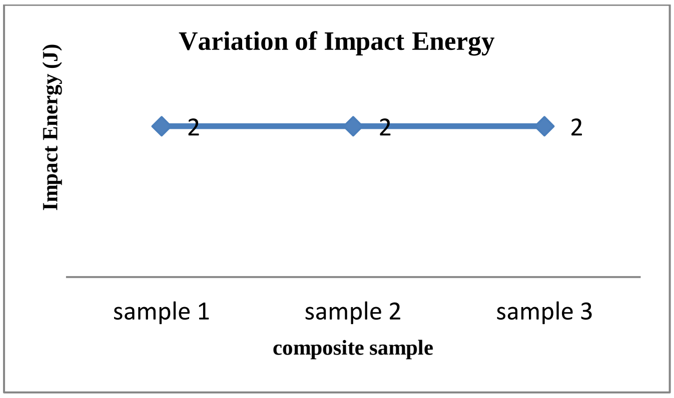

Fig.6.Variation of Impact Energy

3. CORROSION BEHAVIOUR

No traces of rust or oxidation were observed on the surface of composite samples. Samples were exposed to environment where salt mist is sprayed for 24 hours and result was noted down. This corrosion resistance is the reflection of high corrosion resistance of Al LM25.

IV. CONCLUSION

The microstructure, mechanical properties and corrosion behaviour of Al LM25 matrix composites containing 5:5, 3:7, and 7:3 wt % areca leaf sheath ash and silicon carbide as reinforcement was investigated. The results show that:

1. The hardness, percentage elongation and impact energy almost remains same for every composition.
2. Tensile strength and yield strength decreases with increase in ALFA content, although every composition maintains better strength when compared to parent metal
3. Density decreases with increase in ALFA content
4. FESEM results shows uniform distribution of reinforcements in 5:5 composition and also shows a chance for agglomeration in 3:7 and 7:3 composition
5. Salt spray corrosion test conducted for 24 hours shows high corrosion resistance for every composition.

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