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STUDY ON MECHANICAL PROPERTIES OF Al 6061 REINFORCED WITH ARECA LEAF SHEATH ASH

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Abstract - *Natural composites are considered to have potential use as reinforcing material in metal matrix composites because of their good strength, stiffness, low cost, environmental friendly and biodegradable. The present work has been done to develop a new composite using areca leaf sheath ash as reinforcement in different weight fractions with Al6061, by stir casting process. the hardness, tensile tests and wear have been conducted. It is concluded from the investigation that, the addition of areca leaf sheath ash increases the tensile strength and hardness of the material. But above 5% both tensile strength and hardness decreases because of poor wettability. The new composite can be used for making load carrying products like suitcase handles and for making some home appliances.*

Key Words: AL6160, Areca Leaf, composite materials.

1. INTRODUCTION

Extreme need for the metals with high strength to weight ratio has always been the basic and foremost reason for the development of composite materials. Composites with the virtue of their low density, high strength to weight ratio, high temperature strength retention, excellent creep, fatigue and wear resistance have been used has the replacement to cast iron and other materials in automobile parts and in other areas. Generally the composites used for the purpose of automobile construction contain silicon carbide (SiC), aluminium oxide (Al_2O_3) or other particles like magnesium, titanium, aluminium etc.

Aluminium alloys are used in different engineering fields due to its high strength to weight ratio and other mechanical properties. Aluminium alloys are used as main metal matrix element in the composite materials. Aluminium alloys are light-weight, have relatively high strength, retain good ductility, have high resistance to corrosion, and non toxic. Aluminium alloys have a melting range between 482^{0}C and 750^{0}C depending upon the alloy. The reinforcement is added with the aluminium alloy to form composite material. Aluminium composite material exhibits enhanced properties such as young's modulus, toughness, tensile strength both at room and elevated temperatures and significant weight savings over unreinforced alloys.

Natural fibres can be used in many forms in composites, Fly ash, palm oil fuel ash (POFA), palm oil clinker (POC), rice husks, coconut husk and sugarcane bagasse, areca palm leaf sheath are some of the example of waste materials which have potential to be utilized in synthesis of composites. They also possess some of the advantages over other synthetics such as aramid, glass fibre like low density, non abrasiveness, non toxicity, good thermal properties, environmentally friendly, cost effective, energy efficient etc.,

2. CLASSIFICATION OF COMPOSITES:

Composite materials can be mainly classified based on:

1) Matrix Material
2) Reinforcing Material

2.1 Based on Matrix Material

The three types of composites based on the matrix material are:

- **Metal Matrix Composites:** Metal Matrix Composites are composed of a metallic matrix (aluminium, magnesium, iron, cobalt, copper) and a dispersed ceramic (oxides, carbides) or metallic (lead, tungsten, molybdenum) phase as reinforcement.
- **Ceramic Matrix Composites (CMC):** Ceramic Matrix Composites are composed of a ceramic matrix and embedded fibres of other ceramic material as reinforcement (dispersed phase).
- **Polymer Matrix Composites (PMC):** Polymer Matrix Composites are composed of a matrix from thermoset (Unsaturated Polyester(UP), Epoxy(EP)) or thermoplastic (Polycarbonate (PC), Polyvinylchloride, Nylon, Polysterene) and embedded glass, carbon, steel or Kevlar fibres as reinforcement (dispersed phase).

2.2 Based On Reinforcements Used

The three types of composites based on the reinforcements are

- **Particulate Composites:** Particulate composites are other class of particle-reinforced composites. These contain large amounts of comparatively coarse particles. These composites are designed to produce unusual combinations of properties rather than to improve the strength. Mainly there are two types of particulate composites;
  1. Composite with random orientation of particles
  2. Composites with preferred orientation of particles
- **Fibrous Composites:** Most fibre-reinforced composites provide improved strength and other

mechanical properties such as strength-to-weight ratio by incorporating strong and stiff brittle fibres into a softer and more ductile matrix. The matrix material acts as a medium to transfer the load to the fibres, which carry most of the applied load. The matrix also provides protection to fibres from external loads and atmosphere.

- **Laminate Composites:** When a fibre reinforced composite consists of several layers with different fibre orientations, it is called multilayer (angle-ply) composite. The individual layers consist of high-modulus, high-strength fibres in a polymeric, metallic, or ceramic matrix material. Typical fibres used include cellulose, graphite, glass, boron, silicon carbide, and some matrix materials are epoxies, polyamides, aluminium, titanium and alumina.

3. ALUMINIUM ALLOYS

An aluminium alloy composition consists of different materials which are mixed to the aluminium in specific proportion to increase its properties, These various segments incorporate Si, Cu, Mg, Mn and Zn at steps that consolidated to increase as much as 15 percent of the combination from weight. Alloying needs the exhaustive mixing of aluminium with these distinct parts while the aluminium is in molten liquid form.

4. LITERATURE SURVEY

Ankesh kumar, et.al.,[1] analysed the desirable combination of thermo-mechanical properties and machine ability characteristics. Aluminium based matrix composite is still the most explored metal matrix material for the study and enhancement of MMCs (Surappa et al, 2003). The reason why Al is most popular and quite attractive matrix for the metal matrix composite is due to their low density, capability to get strengthened by precipitation, good corrosion resistance, better thermal and electrical conductivities and high damping capacity.

Pardeep Sharma, et.al.,[2] focused on the effect of graphite particles addition on the microstructure of Al6082 metal matrix composites manufactured by conventional stir casting process. By changing the weight fraction of graphite from 0% to 12% the micro structural investigation was made and concluded that the graphite distribution is non-uniform and resulted in decreasing of hardness of the composite.

5. MATERIALS AND EXPERIMENTATION

The materials and procedures in the experimental work required for the completion of the project is given below.

Aluminium 6061(Base metal)

The melting point of most aluminium alloys is near that of pure aluminium, approximately 660°C; this relatively low melting temperature, in comparison to most other potential matrix metals, facilitates easy processing of aluminium based MMCs. (T. W. Clyne, 2001) Further, it is available in various forms for easy processing and a wide range of alloys are available to choose for a particular application.

Figure 5.1 Al6061

Table 5.1 Composition of Al6061

Alloy	Al	Si	Fe	Cu	Ti	Mg	Mn	Zn	Cr
Al6061	97.6	0.62	0.61	0.021	0.53	0.98	0.044	0.72	0.0051

Areca Palm Leaf Sheath Ash Powder (Reinforcement material)

Areca leaf sheath is very abundantly found in our country both in coastal and non-coastal regions, which at this time have very less use and this unusable material, can be used to produce composite materials. Areca nut leaf sheath fibre composed of mainly α-cellulose, lignin, and hemicelluloses. In addition, it contains minor constituents such as pectic matters, Fatty and waxy matters.

Table 5.2 Mineral composition of the areca leaf sheath is given below:

Ca%	P%	S%	Cu ppm
0.23-0.60	0.06-0.08	0.61-0.75	15-23

Figure 5.2 Areca leaf sheath powder

Figure 5.3 Furnace used to heating the areca sheath ash

6. EXPERIMENTAL DETAILS

Following tests were conducted to the prepared composite specimen to investigate the mechanical properties.

1. Hardness test
2. Tensile test
3. Wear Test

6.1 Hardness Test

Hardness test specimens were prepared according to the ASTM E18 standard. The photographic view of testing machine is shown in figure, the specimen used here is circular bar of 20mm dia and length. Hardness for the three separate specimens of three different composition is determined by applying minimum indentation load of 10kg.

Figure 6.1 Hardness Testing Machine

Figure 6.2 Hardness Tested Specimen

6.2 Tensile Test

Tensile strength is the resistance of a material to breaking under tension. Tensile test specimens are prepared according to ASTM standard E8 to measure the tensile strength.

The specimens are prepared to dimensions of 20 mm. tensile strength of three specimens and three reinforced specimens are determined by applying required load.

Tensile tests are performed under ambient or controlled conditions to determine the tensile properties of a material and also to determine the maximum load that a material can sustain without failure. In this test, a sample is subjected to tensile load until the specimen break and ultimate tensile strength is determined.

Figure 6.3 Tensile Tested Specimen

7. RESULTS

7.1 Hardness Test

The hardness test for the three separate specimens of three different weight fraction with different grain size of reinforcement [5% (212 μm), 10% (340 μm) and 15% (425 μm)] and also on the pure aluminium (Al6061 with 0% reinforcement) is determined by applying minimum indentation load of 10kg. The following graph shows the results of hardness for specimens with different weight fractions and with different grain size.

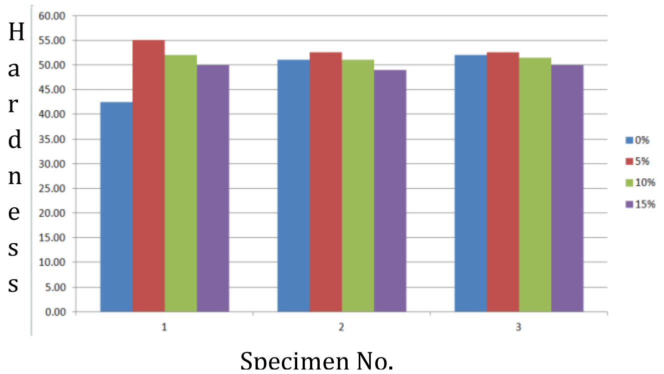

Figure 7.1 Hardness (RHN-B) for different weight fraction of composite material

7.2 Tensile Test

The tensile test was conducted on specimens with different weight fraction of reinforcement [5% (212 μm), 10% (340 μm) and 15% (425 μm)] and on pure Al6061 with 0% reinforcement. The results of tensile test specimens conducted in universal testing machine are discussed below.

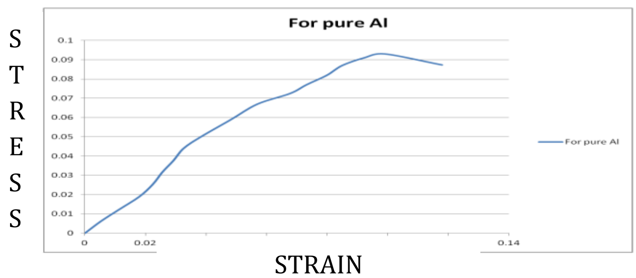

Figure 7.2 Tensile strength of Al6061 with pure Al

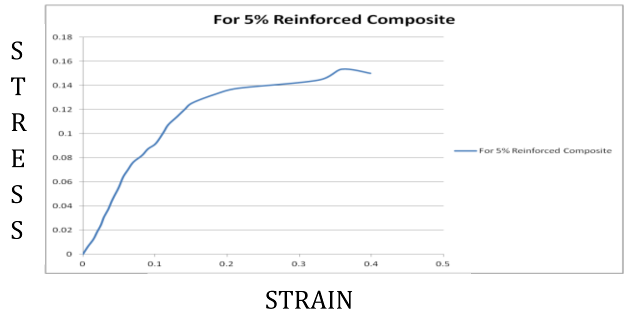

Figure 7.3 Tensile strength of Al6061 with 5% reinforcement

Composite material of Al6061 with 5% reinforcement that a proportional increase in both stress and strain can be seen upto 0.12KN/mm². It is seen that there is slight increase in stress with respect to strain above 0.12KN/mm² in the composite material of Al6061 with5% reinforcement.

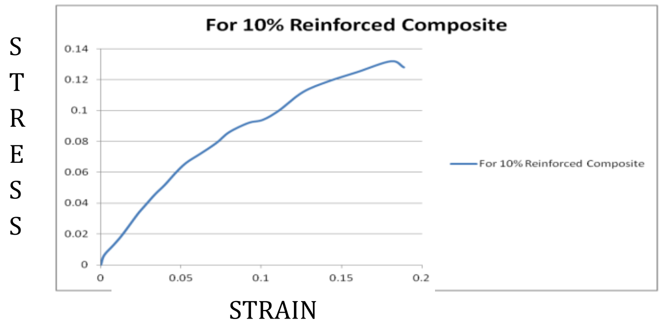

Figure 7.4 Tensile strength of Al6061 with 10% reinforcement

The Stress verses Strain graphs for 10% reinforced composite shown in figure 5.2.3 and the result in same as that of pure aluminium specimen, but they differ in ultimate and breaking load. It can be seen from the graph that the 10% reinforced specimen can withstand a peak load of about 25KN and the material fails at 24KN.

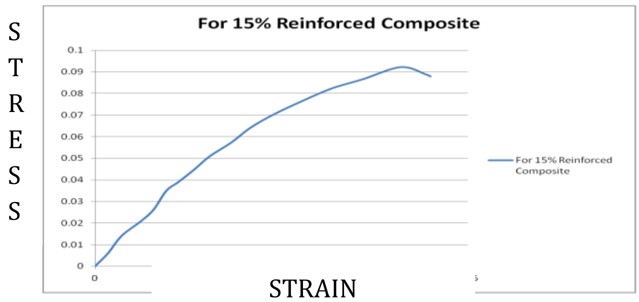

Figure 7.5 Tensile strength of Al6061 with 15% reinforcement

The Stress verses Strain graphs for 15% reinforced composite show similar pattern (fig 5.2.4) as that of pure aluminium specimen, but they differ in ultimate and breaking load. It can be seen from the graph that a 15% reinforced composite can withstand a load of 20KN and breaking load of 17KN.

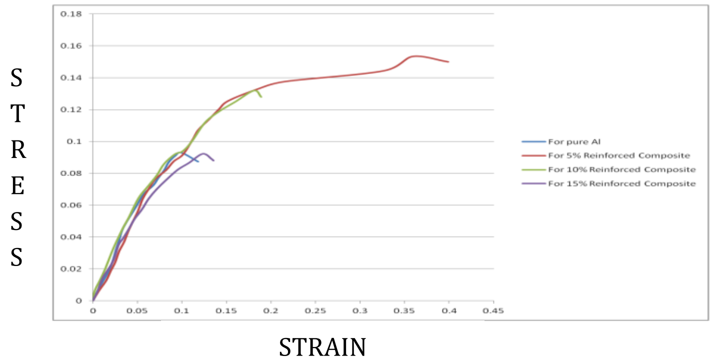

Figure 7.6 comparison graph of tensile strength

7.3 WEAR TEST

The test for dry sliding wear at room temperature is performed by using pin-on-disc wear test Rig. Parameters selected for testing are load, speed and time and these are list in the Table 7.1

Table 7.1 Process Parameters

Parameters	Trials		
	1	2	3
Load (kg)	0.5	1.0	1.5
Speed (rpm)	500	1000	1500
Time (sec)	191	95	62

5.3.1 Influence of Load on Wear Behaviour

Below figures indicate the result of wear test of composite samples at different load (0.5kg, 1kg and 1.5kg) keeping constant as Time and Speed. It is observed that wear increases from 0.5kg to 1.5kg for each specimen for both materials as shown in the graph. This is due to the increase of the load friction between specimen and disc. Therefore wear increases with increasing the Load. The comparison with pure Al6061 with composite material wear is more on Pure Al6061 material and hence it is proved that the wear property of the composite is more compare to Al6061 material as shown in the figures.

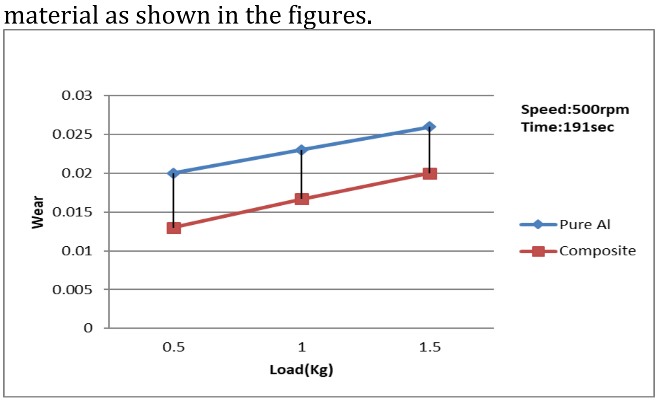

Fig. 7.7 Effect of load on Wear with Speed 500rpm

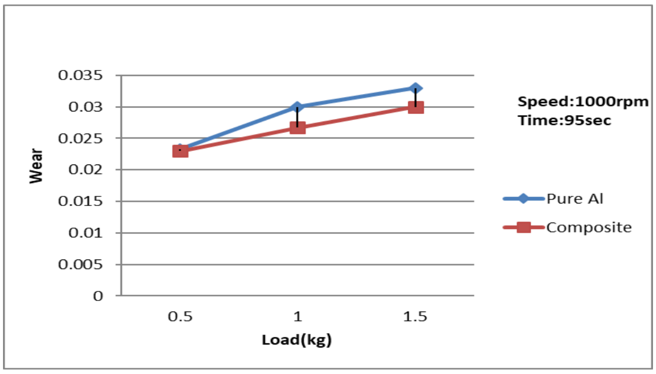

Fig 7.8 Effect of Load on Wear with Speed 1000 rpm

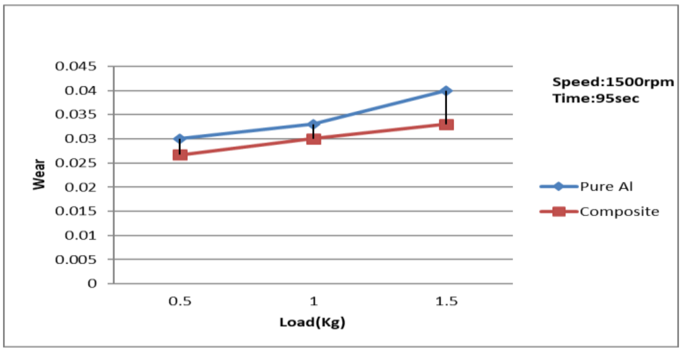

Fig 7.9 Effect of Load on Wear with Speed 1500 rpm

5.3.2 Influence of Speed on Wear Behaviour

Below figure indicate the result of wear test of composite samples at different Speed (500rpm, 1000rpm and 1500rpm) keeping Load as constant. It is observed that wear increases from 500rpm to 1500rpm for each specimen for both materials as shown in the graph. This is because as friction between the specimen and the rotating disc is raised. Therefore wear increases with increasing the Speed. The comparison with pure Al6061 with composite material wear is more on Pure Al6061 material and hence it is proved that the wear property of the composite is more compare to Al6061 material as shown in the below figures.

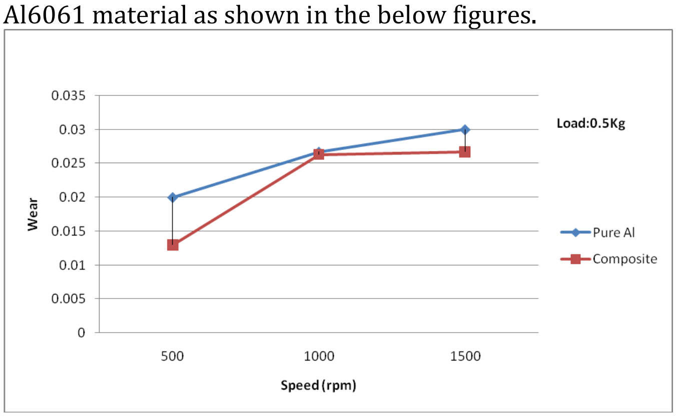

Fig. 7.10 Effect of Speed on Wear with Load 0.5Kg

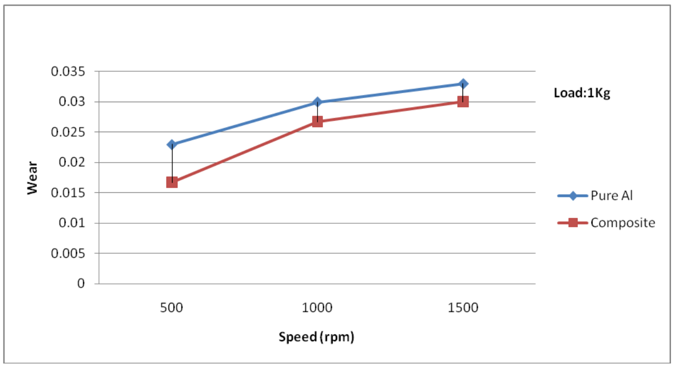

Fig. 7.11 Effect of Speed on Wear with Load 1Kg

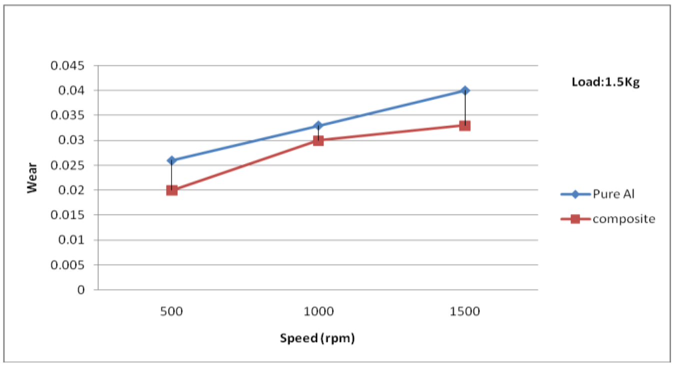

Fig. 7.12 Effect of Speed on Wear with Load 1.5Kg

8. CONCLUSIONS

The following conclusions can be drawn from the experimental results of present work.

1. The new composite is developed using areca leaf sheath ash in different weight fraction with Al6061.
2. Hardness test results show that there is increase in hardness with increasing weight fraction of (areca leaf sheath) reinforcement particles upto 5%.
3. Addition of areca leaf sheath ash will increase the tensile strength of the composite upto 5%. Furthermore the increase in weight fraction revealed the decrease in the tensile strength of the composite.
4. The new composite is used for making load carrying products like suitcase handle and some home appliances.
5. The speed of rotation of the specimen has shown influence on wear rate. As speed increases the wear rate will also increases. This is because the high velocity impingement of the abrasive at high speeds.

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