Analysis on Tribiological Behaviour in Sugarcane Bagasse Ash Reinforced Aa6063 Composite

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Abstract— **In this analysis, Aluminum 6063 (AA6063) is used as matrix material and sugarcane bagasse ash (SCBA) is used as reinforcement material and combinedly cast to produce Metal Matrix Composite (MMC). Particle size of reinforcement is 75µm with varying composition from 0% to 3% is fabricated by stir casting technique. The effect of percentage reinforcement on the particle dispersion and strength of MMC's are studied. The microstructures were examined under optical microscope. Cast composites were characterized for mechanical properties with respect to wt. percentage of SCB and it is observed that the hardness and tensile strength were increased as reinforcement increased. The dry sliding wear behavior of the cast composites were studied using pin on disc apparatus. Experiments were conducted varying the loads from 2kg to 3 kg, for a constant distance of 5000m and constant sliding speed of 500 rpm. Sliding wear resistance has been increased for reinforced alloy as compared to AA6063 alloy and also resistance increased as reinforcement increased.**

Key Words: AA6063, sugar cane bagasse ash, sliding wear, hardness, Micro structure.

1. INTRODUCTION

In the fast innovating world the need of new materials has never been higher, precisely thus have the metal matrix composites (MMCs) developed, with their high weight to strength ratio and very high wear resistance the MMCs are rapidly gaining importance. In this study the MMC under consideration is the aluminum alloy AA6063 reinforced with sugarcane bagasse ash which is a byproduct of sugarcane industry (fly ash obtained by burning of sugarcane waste). A number of studies have been made on aluminum matrixes using fly ash and similar number of observations have been made on their mechanical, structural, tribological and particle sizes. One might ask why another study? Out of all the other fly ashes bagasse ash is the most inexpensive and has very less density and is abundantly available in mass as waste from sugarcane industries. Sugarcane bagasse ash powder, as it is rich in alumina (Al2O3) and silica (SiO2). This can enhance the mechanical properties of Metal Matrix Composites (MMC). The physical, mechanical properties vary mainly with the size and structure of reinforce materials. S.B. Hassan, V.S. Aigbodion had studied the microstructure of Al-Cu-Mg/Bagasse ash particulate composite and had found that there are interfacial reactions with SiO2, Sic and Fe2O3. They varied the wt.pct. From 0 to 10 in intervals of 2 while carefully maintaining the average particle size as 63µm they also studied wear properties of combination of adhesion and delamination wear was in operation and concluded the resistance to wear increases. Y.C. Kang, S.L. Chan studied the variation in the mechanical properties of the composites in accordance with the reinforcement particle size, particle larger than 1.5µm acts as micro concentrator sand are prone to cleavage, while particles in the range of 200 – 1500 nm reportedly formed cavities and pits due to their poor interphase cohesion, but particles less than 200 nm bonded well with host metal matrix and is regarded as the key to the excellent mechanical properties of MMNC. M. Cournil, F. Gruy et al gave model a for aggregation of solid particles in non-wetting liquid medium. They noted that the odds of agglomeration and clustering increased when the particles are not wetted by the molten matrix. The tendency to form agglomerates and clusters is explained using Gibbs free energy. S. Melis, M. Verduyn et al [4] in their study pressed on the effect of particle size and surface energies. As particle size falls down to Nano scale surface energies increases which gives rise to thermodynamic effect and the layers of gas begin to form on the particle surfaces. The high surface energy problem can be negated by using stir casting methods which increases a thorough mixture of the participating molecules.

Al	Mg	Si	Fe	Mn	Cu	Zn	Cr	Others
Balance	0.8-1.2	0.4-0.8	0.7	0.5	0.15-0.4	0.25	0.04-0.35	0.05

2. EXPERIMENT PROCEDURE

2.1. Fabrication Process

The reinforcement material Sugarcane Bagasse Ash (SCBA) is collected from Etikoppaka sugar factory, Darlapudi, Visakhapatnam, Andhra Pradesh. Chemical composition is given below in table 1.

SiO_2	Al_2O_3	Fe_2O_3	CaO	MnO	SO_3	K_2O	Na_2O	Others	LOI
78.9	8.55	3.6	2.15	.13	.49	3.16	.38	Balance	.42

Table 1 Chemical composition of SCBA

The average particle size is obtained by sieve analyzer with different sieves as 75 µm.

The metal matrix Aluminum AA6063 chemical composition is given in Table 2.

Table 2. Chemical composition of AA6063

The basic requirement to prep. The SCBA is to preheat it at 250^{0}C to eliminate moisture, this reduces particle agglomeration drastically improving wettability and dispersion of the particles with the molten AA6063 metal. A predetermined quantity of PureAA6063 alloy is taken and heated in a graphite crucible well above the melting point in furnace so as to achieve 100% molten aluminum alloy. To increase the wettability of the particles 1% by weight magnesium is added into the molten metal, as the temperature reaches to 700^{0}C the preheated SCBA particles are added while stirring simultaneously for uniform texture and mixing of the particles the stirring is continued for 8-10 min after adding of particles. To ensure that the metal and fly ash particles are properly mixed the mixture is then superheated to 800oC whilst stirring is being performed before being cast in preheated dies. The percentages of fly ash used in making Metal matrix composites are varied from 1%, 2%and 3% by weight. The addition of magnesium in small quantities improves the wetting characteristics it is shown that 1wt% magnesium addition causes the surface energy of aluminum to drop from 860dyne/cm to 650dyne/cm [6]. The stir time and speed have to be maintained so as to ensure uniform distribution of reinforcement particles in the matrix [14].

2.2 MECHANICAL PROPERTIES

2.2.1 Tensile Testing

Tensile testing is conducted on an Instron 8801 machine universal testing machine at room temperature. The device is a displacement-controlled load frame. Cylindrical cross-section tensile samples are used. The results are then tabulated based on three tests.

2.2.2 Micro Hardness

Micro hardness is a property showcased by the intermolecular bonds and grain structure. Vickers Hardness tester is used to study the hardness of the cast cylindrical samples. A 1kg load is applied for 15 seconds at a speed of 60µm/s. An average of 5 measurements was taken.

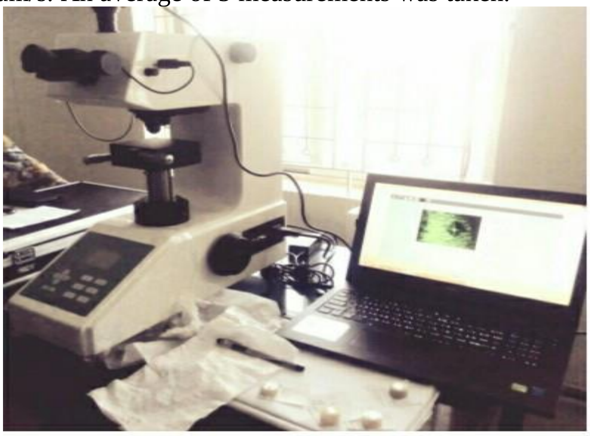

Fig.1 Vickers Hardness tester

2.3 Characterization of Samples

Samples for microstructure evaluation were cut and ground by the emery paper of grit size in the successive steps of 180, 220, 320,400,500, 600 and 800 microns with water as coolant followed by polishing on velvet 1µm to get the mirrored surface. Etching is done on to specimen before micro structural study. Keller’s reagent was used as etchant solution on metal matrix composite samples, to optically enhance micro structural features such as grain size and phase features. Olympus Mituoyo Optical Microscope (OM), Camera with zoom extents 5x to 100x in conjunction with Dewinter Professional Edition software was used for observation of the microstructure and image analysis.

2.4 Wear Test

A DuCOM tribometer was used to investigate the dry sliding wear behavior of the AA6063 MMC composite specimens. The setup consists of a pin on the pin type specimen the sliding wear tests were conducted in dry environment as per ASTM G99 standards.5mm diameter pins were taken as wear specimens which were about 30mm long, for better accuracy of the result the cast specimens are cast, machined and then polished by emery paper numbering in the sequence of 180,220, 320, 400,600 and 800. The samples are ground and polished by using polishing machine. The initial weight of the specimen was measured in a single pan electronic weighing machine with a least count of 0.0001g. During the test the pin was pressed against the counterpart rotating against EN-32 (Hardness 65 HRC) steel disc by applying the load at room temperature as shown in Figure 5. The loads of 10N, 20N and 30N at constant wear track diameter of 1000m at constant 500rpm for each specimen the frictional force and wear were recorded.

Figure 2 Pin on Disc apparatus.

3. RESULTS AND DISCUSSIONS

The mechanical properties of composite depend on the type of bonding, structural arrangement, porosity and dislocations. In this section the hardness, tensile properties of specimens were compared and analyzed.

3.1 Tensile Strength

Table3. Tensile test results

Sl. No	Specimen	Tensile Strength (MPa)	%elongation
1	AA6063	112	6.1
2	AA6063 + 1%SCBA	122.2802	1.209
3	AA6063 + 2%SCBA	125.4014	1.075
4	AA6063 + 3% SCBA	126.1285	0.949

From the above results, with addition of reinforcement the tensile strength of the material by an incredible 12.6% but the ductility is compromised as the percent elongation decreased by almost 40%.

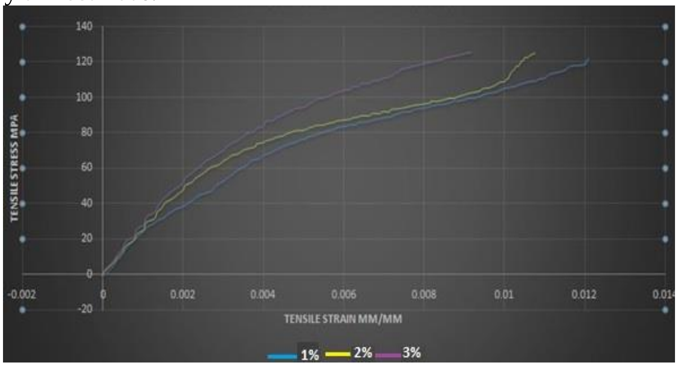

Fig.3 tensile stress vs strain diagram

3.2 Micro Hardness

Table 4 Hardness test results

PERCENTAGE	HV
AA6063	68.97
AA6063+1% SCBA	75.34
AA6063+2% SCBA	78.75
AA6063+3% SCBA	79.97

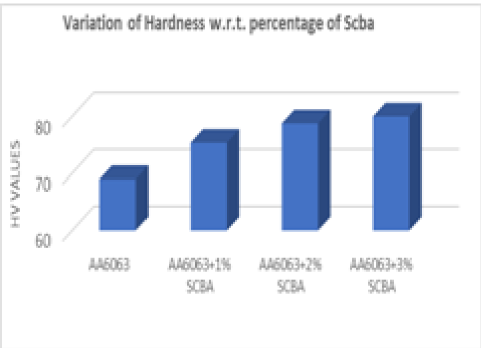

Fig.4 Hardness Vs %of SCBA

It is clearly seen that the hardness of the MMC is increased as the percentage of the reinforcement material is increased. The increase in hardness of the composites can be attributed to SiC and Al2O3 in reinforcement which has combined pinning effect of SiC, and increased hardness also makes it much harder for the material to undergo plastic deformation. Since agglomerations increase the hardness value the tests are conducted at different locations and average value is reported.

3.3 Microstructures

In fig5(c), it can be seen that the particles are not uniformly distributed in the metal, whereas in fig5 (d) the SCBA particles are more uniformly distributed in the metal matrix thus improving properties. The ceramic phase is shown in dark and the metal phase is white.

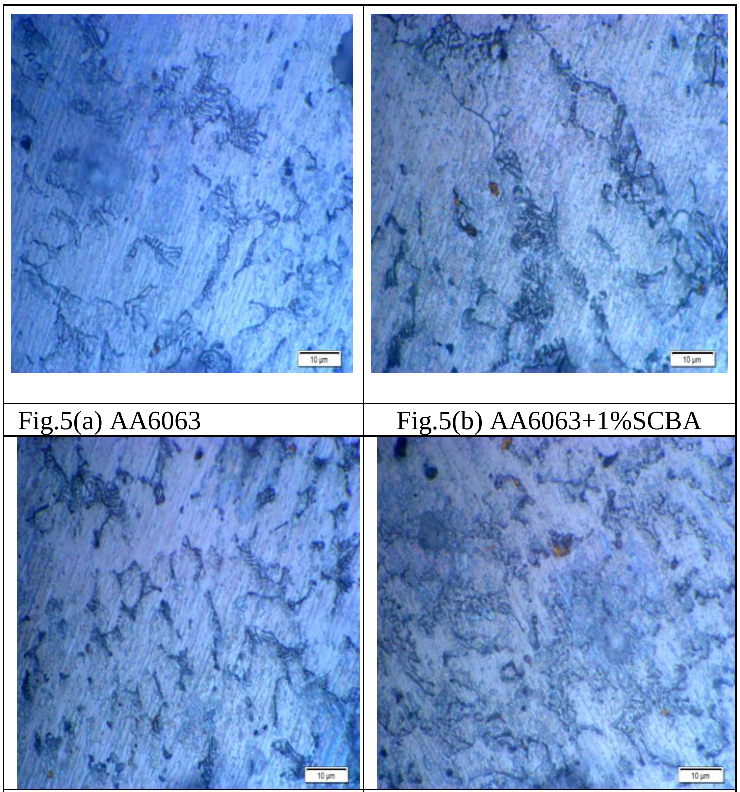

Fig.5(a) AA6063 | Fig.5(b) AA6063+1%SCBA

Fig.5(c) AA6063+2%SCBA | Fig.5(d) AA6063+3%SCBA

Fig.5 Microstructures of the cast samples

3.4 Dry Sliding Wear

The test parameters for the dry wear are shown in table 5

Table 5 Parameters for the dry wear

Parameter	Value
Load	2kg,3kg
Speed	500RPM
Time	25 Minutes
Temperature	Room Temperature

It is observed that wear rate increases linearly with increase in distance for all loads and % reinforcements. The wear rate is less for SCBA reinforced AA6063 when compared to unreinforced. As load increased the wear has been increased in both reinforced and unreinforced composites. But the increase in wear of AA6063 alloy is more when compared to reinforced alloy. From all the three graphs it is evident that with increase in reinforcement wear rate decreased. Wear resistance improvement is due to the presence of Si ceramic particles which increases the hardness of Al MMC.

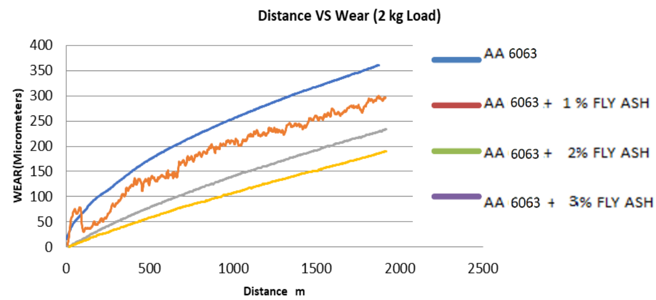

Fig.6 Distance Vs Wear at 2 kg Load

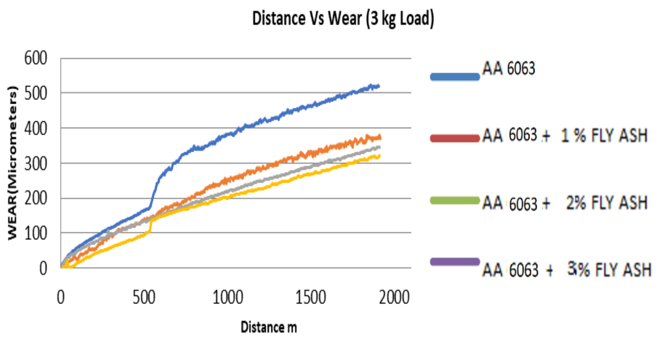

Fig.7 Distance Vs Wear at 3 kg Load

4. CONCLUSIONS

1. Successful fabrication of Aluminum composite with reinforcement of sugar cane bagasse ash of particle size 75µm using stir casting technique.
2. As the reinforcement percentage increased, the tensile strength increased due to homogenous distribution of SCBA particles in the matrix.
3. With the increase in reinforcement percentage, the hardness increased due to the strong particles present in reinforcement.
4. The AA6063- SCBA composite exhibited better wear resistance than unreinforced alloy even at higher loads and distances. And it is also observed that the volume of SCBA added in MMC has affected the wear rate. With increased weight %of reinforcement, the wear rate decreased.

5. REFERENCE

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