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Wear Behavior of Aluminum Based Composite Reinforced With Coconut Shell Ash

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Abstract: *In the present scenario using Optimization technique the Wear rate and Coefficient of Friction can be minimized significantly by taking aluminium metal matrix composites (Al-MMCs) as the base material as Al and the reinforcement with (5-10)% Coconut shell Ash. The change in hardness and tensile strength values were noted and studied. Hardness and wear studies of the material have been done to judge the surface mechanical properties of the composites prepared. This work mainly deals with the identification of the characteristics of Coconut Shell Ash using Spectroscopic and Microscopic analysis.*

Key words: *MMCs, CSA, wear, microstructure, mechanical properties.*

1. Introduction

Nowadays the used composites are most Attractive is considered and used metal matrix composites all over the World. Many scientist and researcher are using the most unusual combination of properties with the help of modern technology which was cannot be done by traditional polymeric, ceramic materials and metal alloys [1].The reinforcement of Coconut shell ash into aluminium alloys (Al) greatly enhanced the mechanical properties like low wear rate, damping capacity, low Coefficient of Friction, increase the corrosive resistance and strength at low speed. MMCs are used in a different application in the Aerospace, defense sector, electronics, thermal management and Wear applications [2]. But many problems are found in Automobile components like Wear & tear, the weight ratio is not balanced and many others. So, CSA is added in Al-MMCs to improve the properties. As Coconut shell, ash is agricultural waste. The waste is produced in abundance globally and poses a risk to health as well to the environment. Since the utilization of CSA is always a challenge for researchers. This waste utilization is not only used in controlling pollutions but also economical [3].

Composite materials are the combination of two or more different materials which results in better properties than those of the individual Components used alone[4,5] As compared to that of metallic alloys ,each material retains its separate chemical, physical, and mechanical properties. The two constituents which are required are reinforcement and matrix. The main advantages of composite materials are stiffness, resistance to wear, high strength, combined with low density, which when compared with any other bulk materials, allowing for a weight reduction in the finished part [6].

Metal matrix composites mainly consist of main whisker, continuous and discontinuous fibers and many different particles of small sizes in the matrix which is in the form of alloy [7], which reinforce the matrix and provide the different properties which are not achievable by different alloys. Such necessary and required properties can be achieved only when the constituents of different nature are mixed properly [8]. The matrix which is the most important element can be an alloy or even a ductile metal [9]. Many different metal alloys are now available like aluminium, copper, magnesium and titanium.

Reinforcement means the addition of a certain element to the base metal to increase its properties like mechanical properties, physical and chemical properties [10].The reinforced material should not form intermetallic compound with the matrix element and also it should be highly stable. In this experimental work, the authors preferred coconut shell ash as reinforcement [11]. The main objective is to increase the mechanical properties like hardness, tensile strength, toughness, strength, stiffness and increase the wear resistance. Many different particles which are hard like Al_2O_3, SiC, $B_4C$are mostly used as reinforcement in different composites. For making piston, connecting rod and cylinder head, Al metal matrix composites are mainly used which provide necessary strength, wear and stiffness of the components [12] many processing technique are like liquid and powder metallurgy routes for fabrication purpose, the mechanical properties which are very sensitive to this. Many modern scientific optimizing techniques have been in used for the improvement of the metal matrix composites [13, 14].

Raju[1] studied the Optimization of Machinability Properties on Aluminium Metal Matrix Composite Prepared By In-Situ Ceramic Mixture Using Coconut Shell Ash -Taguchi Approach. Agynsoye [2] studied morphology and mechanical behaviour of coconut shell reinforced polyethylene composite was prepared by compacting low-density metal matrix with 5-25% volume fraction of coconut shell particles. The result obtained to be is that hardness of the composite increases with increase in coconut shell content whereas the tensile strength, modulus of elasticity, ductility and the impact of the energy of the composite decreases with increase in the particle content. Durowaye [3] studied the mechanical properties of particulate coconut shell with the addition of palm fruit matrix composites and found the ultimate tensile strength value was 70MPa, the highest impact strength was 4.76J, and highest hardness value was 208 BHN for the coconut shell particulate polyester composite For the above values weight % (reinforcement) must be kept below 10 and 20% respectively. This study showed coconut shell particles enhanced the mechanical properties of the polyester matrix composites. Basavaraj and Bharat [4] report the mechanical behavior of pure aluminum reinforced with the alloy of Silicon Carbide and coconut shell ash which was fabricated by liquid metallurgical (stir casting) method". It was found that tensile strength increases with increase in rice husk whereas decreases with a decrease in rice husk content. The impact strength and hardness of the composite increases with increase in Sic content while it slightly decreases with increase in rice husk content. Ankit and Muni [6] studied the mechanical behaviour of aluminum alloy used as the matrix, RHA and copper as the reinforcements. RHA is the only agricultural waste that contains the larger amount of silica in it. This experiment results showed that a good hardness and strength of these composite can find application where lightweight materials are supposed to be required. The hardness of prepared composites is increased by increasing rice husk ash and copper content. Kowk and Lim studied [7] the size of the Sic reinforcement particles appeared to be an important factor in the high-speed tribological behavior of the composites". The results obtained suggest that a small particle size which leads to high speed wear resistance, with the composites experiencing extensive melting even when a relatively low load is applied. Al/Sic composites with small Sic particles are therefore more suitable for low-speed applications.

Lin and Lee [8] studied the influence of cutting conditions during turning of Al/Sic-MMC on surface finish. In this Study, the Taguchi method, one of the most important and a powerful tool for experiment and Design was done to optimize the cutting parameters for the effective turning of Al/Sic-MMC. Boopathi et.al [9] deals with the mechanical properties of Al 2024 in the presence of silicon carbide, coconut shell and its combinations. The compositions were added up to the ultimate level and stir casting method was used for the fabrication of aluminium metal matrix composites. Aluminium in the presence of SiC-coconut shell was the hardest instead of aluminium-SiC and aluminium-coconut shell composites. Rohatgi et.al [10] reported that the feasibility of incorporating coconut shell ash in die-cast magnesium alloy and investigated some of the salient physical and mechanical properties of magnesium alloy metal matrix composites. This result showed that the presence of 10 wt. % cenospheres decreased the compressive strength and compressive yield strength of the composite relative to that of the AZ91D matrix alloy.

Arun et al [11] conducted an experiment on Aluminium alloy composite where they found these composites are hard, rigid, and tough and possess good mechanical properties their ductility will decrease and will gain better resistance to corrosion. It was observed that Tensile strength of composite was enhanced and at 15% coconut shell ash it is maximum when compared with Al6061 T6 it was increased by23.26%. Lokesh et al [12] study on Tensile and wear behaviour of Al-4.5%Cu alloy reinforced coconut shell/SiC by stir and squeeze casting with rolled composites. The results indicate that the hardness and tensile strength increases with increase in the percentage of coconut shell and SiC by stir squeeze and rolled composites. The test results showed that rolled specimens fabricated by stir casting technique have greater wear resistance than those fabricated by squeeze casting technique.

Ankush et al [13] presented in this investigation reveal the effect of the reinforcement on Mechanical properties of Al5052 alloy Composites which were fabricated by the stir casting method. Thus, it can be concluded that the optimum fabrication conditions of the composite processing were provided with above-written composition. Pallavi [14] studied the changes in the mechanical properties of the Al-based MMC composites that are synthesized by reinforcing the amorphous nano-sized (32-56nm) rice husk SiO_2 particles and metallurgical grade SiO_2 particles (10μm) in Al-Mg alloy by liquid metallurgical route with varying percentage of Mg. The microhardness of the Al-Mg- SiO_2 was found to be maximum for 2.5% of Mg and by using rice husk SiO_2 which is of nanostructure in dimension and used as a reinforcement. Wear lose in this composition is found to be less.

2. Preparation of composite

To improve the Wear resistance and Coefficient of friction of MMCs. Stir casting method is introduced as one type of fabrication process. This method is mainly used for achieving a high level of Mechanical properties in the composites. This method will be used by many researchers. As it is the simplest and cheapest method to fabricate composites. Stir Casting is a liquid state method of composite materials fabrication in which reinforced particles like Coconut shell ash are mixed with Al molten metal matrix composites by means of a mechanical stirrer. At first AL alloy was melted in a crucible and it is heated in a furnace around (700-800) degree Celsius for 20-30 minutes. And at that time, Coconut shell ash was preheated at 700 degrees and after that, it is added into the pouring system consisting of Al alloy. The temperature of the furnace is raised above the temperature of the liquid casting to keep the slurry i.e. the mixture of Al MMCs and Coconut shell ash is in semisolid state. Then Mechanical stirrer will be done, in this process Optimum casting parameter must be taken care of like pouring temperature of molten metal into the pouring system and time required to stir. In this process, the important thing is that proper Mechanical stirring is to be done when reinforcement is added to the Al melt the Liquid composite material is then cast by a conventional casting process (1). Then Degassing agent (mainly hexachord ethane) will be used to decrease the gas porosities. The particles will be distributed in a proper manner to get the final semi-solid, which is depends on the melting temperature and position and size of a mechanical stirrer, solidification time and the amount of reinforced particle added to the MMCs. At last, the molten metal was poured into the mould cavity of proper diameter and length. And then the die is there in the cavity for 5-6 hours and then the Cast material is ready for the experiment and is taken out of the cavity. But the problem with the Stir casting process is the separation of reinforcing particle due to the settling of particles during solidification.

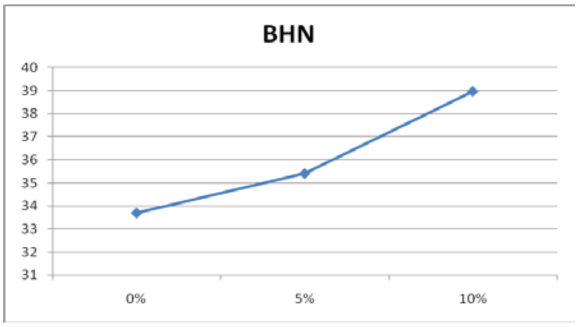

Figure 1: Brinell hardness of Composite

3. Hardness and Tensile Strength Test

The ability of the material to resist the plastic deformation of the material from the standard source is generally considered as hardness. Hardness test was carried out using Brinell cum Rockwell hardness tester. The samples were prepared and polished to provide a scratch free test surface. Tungsten Carbide ball indenter of 20mm with 3mm tip was used for Brinell Hardness Test.

The tensile strength of the AMC specimens was measured through an electronic tensiometer .The specimens were made as per the standards. The device tensometer is mainly used to determine the tensile strength of the specimen. The specimens for tensometer test were loaded between two grips and were adjusted manually. By the means of electronic control, a constantly increasing force was applied to the specimen. The load and elongation were continuously recorded. Then the UTS and percentage elongation was calculated. The ductility, proof strength and young modulus are can be determined by tensometer.

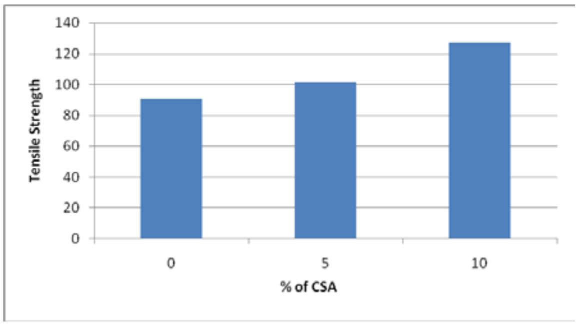

Figure 2: Tensile strength of composites

4. wear test

Finally, wear testing of all the samples was carried out. Wear testing in terms of sliding wear resistance of all the samples was evaluated using a pin on disc type wear testing instrument (DUCOM TR-206) having a hardened steel disc. Tests were carried out with an applied load of 3 kg, 65 tack diameter, 441 rpm rotating speed and 22 min time for the wear test. The results for the wear depth were obtained and the sliding distances were calculated by using the values of the wear depth and the process parameters. Graphs were plotted between the wear depth and sliding distance at a particular load for different compositions of CSA. The wear surfaces were once again taken for SEM analysis. The SEM images obtained for the wear surfaces of different samples were analyzed.

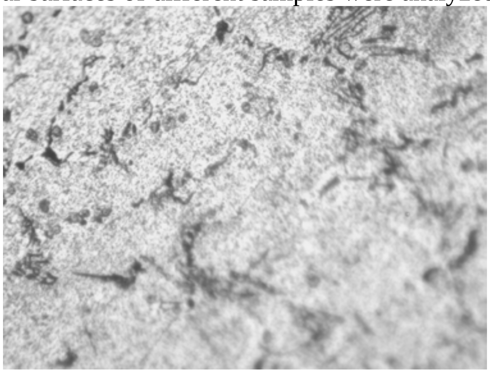

Figure 3 Micro structure of Aluminium

5. Result and discussion:

5.1. Mechanical properties:

Figure 1 represents the hardness of composite increase with increase of reinforcement due to hard face of reinforcement and uniform distribution of particle in the matrix which strength the material. Hardness also increases with the increase in sintering temperature for a particular composition of CSA. This happens because as the sintering temperature increases the voids get reduced in number due to better bonding between the particles. Similarly Figure 2, the tensile strength increase with increase of reinforcement and decrease of percentage of elongation due to the brittleness of material. Particle moment has been difficult due to reinforced material which improves the hardness and tensile strength.

From Figure 3, the microstructure of aluminium matrix indicates ductile material, contains larger in grain sizes. Figure4, The metallography indicates the distributions of particles are uniformly in throughout the matrix and revealed uniform grain sizes and smaller in size.

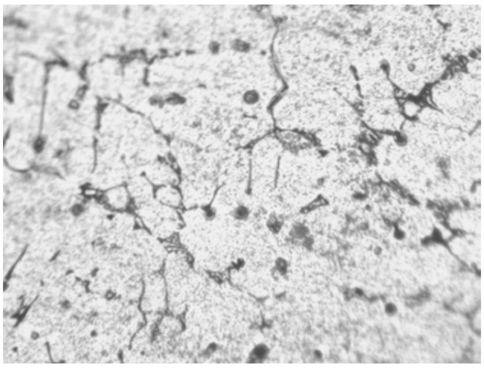

Figure 4: Microstructure of Al-10% of CSA

5.2. Wear behaviour phenomenon

Wear is one of the most important and required phenomenon for all the metal which have relative motion such as rotary motion and reciprocating motion. Basically, one of the challenging jobs in solving the wear criteria is to anticipate the type of wear and identify to which the component it will be subjected. All the experiments are conducted at constant track diameter 65mm, sliding distance of 1000 meters and a load of 3kg and various percent of reinforcement i.e. pure, 5%CSA and 10% of CSA. Figure5 indicates time as a constant parameter and variable parameter as a percentage of reinforcement (CSA).

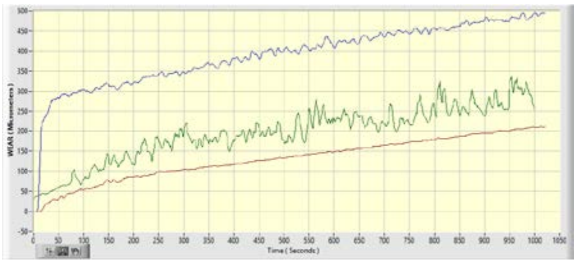

Figure 5: Time vs. Wear (µm)

Three line colors are identified i.e. red, green and blue. Red color indicates 10% of CSA, Green color indicates 5%CSA and blue indicate pure aluminium. From the above diagram represents while % of reinforcement increases wear decreases due to capable of harder particles provides more wear resistance

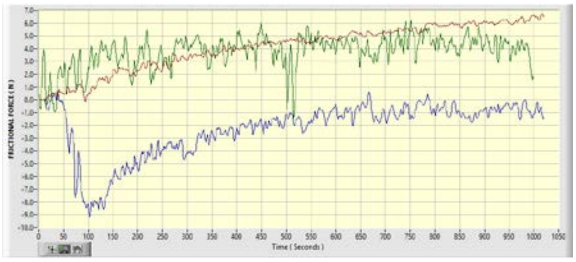

Figure 6: Time vs. frictional force

From Figure 6, frictional force increase with time increases. Similarly, while the reinforcement increases frictional force decreases due to the formation of mechanical mixed layer. The wear mechanism is mainly obtained by the mechanically mixed layer, stability of the oxide layer formation and also due to sub surface deformation.

Figure 7: Time vs. Coefficient of friction

Figure 7, while reinforcement increases coefficient of friction decreases due to the formation of carbon at high temperature which converts into graphite. Those acts like a self-lubrication properties. The overall results shows that the alumina alloy which is used and considered as one of the prime and important material which gives good indication of wear-resistance and coefficient of friction .which are considered as the important factor.

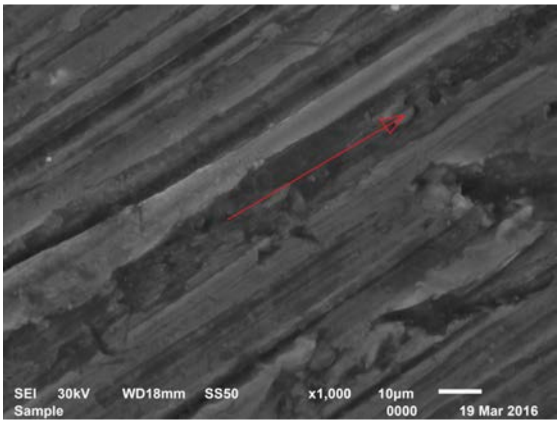

Figure 8 :worn-out surface of 5% of CSA

Figure 8 it clearly indicating that, wear mechanism held between the counter disc and pin material. The figure revealed ploughing of material occur due to hard face particles and its debris is pulled out the matrix which is due to increase of load coefficient of friction and frictional force increase this cause the increase in temperature of the matrix , become soften the material which causes easy ploughing effect. The desertion of the arrow indicates sliding direction.

6. Conclusion:

- The Hardness and Tensile strength increase with the increase in CSA content of reinforcement are 5 and 10% of Vol.
- The wear decreases with increase in the percentage of CSA in the aluminum matrix i.e. wear resistance of the composite increases with increase in CSA content.
- The wear rate is inversely proportional to the hardness values. The increase in CSA, hardness increased.
- With the increase in CSA composition, there was an increase in the coefficient of friction amount of abrasive wear on the surface due to more rubbing activity by the CSA particles.

7. Acknowledgements

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