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MECHANICAL AND TRIBOLOGICAL PROPERTIES OF ALUMINIUM 6061 ALLOY WITH FLYASH AND ZIRCONIA FLOUR HMMCs

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Abstract - *The present paper deals with results of an experimental investigation of effect of reinforcement (Fly ash +Zirconia Flour) on mechanical properties and tribological properties of aluminium alloy (Al 6061) composites samples, processed by stir casting method are reported. Three sets of composites were prepared with fixed percentage of fly ash (3%) & varying percentage of Zirconia Flour (2%, 4% & 6%) by weight fraction. The evaluated properties of the samples were tensile strength, hardness and wear. In the presence of Zirconia Flour 6wt% and fly ash 3wt% with aluminium 6061, it was fairly observed that the hardness was increased by Correspondingly, the increase in tensile strength was also observed and also wear rate decreases with the hybrid metal matrix composites in comparison with unreinforced aluminium 6061 was decreased. From the experiment it was observed that the best properties were obtained from the sample containing Al6061 with Fly ash (3wt%)+ Zirconia Flour (6wt%) as compared to the base metal.*

Key Words: *Aluminium Matrix Composite, Zirconia flour,Fly ash,Stir Casting,Tensile,Hardness,Wear.*

1 .INTRODUCTION

A Composite is a blend of at least two disparate materials having an unmistakable interface between them with the end goal that the properties of the subsequent material are more prominent than the individual constituting parts.

Aluminium alloy based metal matrix composites (AMMCs) have been now established themselves in various engineering fields due to their low weight to density ratio. Al alloys are quite attractive due to their high thermal and electrical conductivity, Corrosion resistance, Ductility, Reflectivity etc. In many cases, the performance of metal-matrix composites is superior in terms of improved physical, mechanical, and thermal properties (specific strength and modulus, elevated temperature stability, thermal conductivity and controlled coefficient of thermal expansion). The intrinsic advantage of MMCs over the unreinforced alloy is the improvement of mechanical properties due to addition of the reinforcement material[1-3]. The most important parameter is volume fraction reported that the important factor controlling elastic modulus is volume fraction of particles. Moreover, as the volume fraction of particles is increased, tensile and yield strengths generally increases and fracture toughness decreases [4-6].

1.1 Aluminium 6061

Al 6061 is a precipitation cementing aluminum, containing magnesium and silicon as its major alloying parts. At first called "Mix 61S," it was made in 1935. It has extraordinary mechanical properties and showcases incredible weldability. It is a champion among the most broadly perceived composites of aluminum for all around valuable use. It is typically available in pre-tempered assessments, for instance, 6061-O (annealed).

Fig 1.1 Al 6061

Table 1.Chemical composition of aluminium 6061

Mg (Magnesium)	0.920 %
Si (Silicon)	0.750%
Fe (Ferrous)	0.280 %
Cu (Copper)	0.220 %

Ti (Titanium)	0.100 %
Cr (Chromium)	0.070 %
Zn (Zinc)	0.060 %
Mn (Manganese)	0.040 %
Be (Beryllium)	0.003 %
V (Vanadium)	0.010 %
Al (Aluminium)	Balance

1.2 Fly ash

Fly fiery remains particles (as a rule of size 0.5-100 micron) which are removed from developments delivered in the consuming of coal. Fly powder has low thickness having extraordinary wetability between fly blazing remains and system Al composite. It has insignificant exertion with inclinations like isotropic properties and the probability of discretionary get ready. It has high electrical resistivity and low warm conductivity. It have low thickness of fly-super hot remains might be useful for making a light weight composites.

Fig 1.2 Fly Ash

1.3 Zirconia flour

Zircon (Zirconium Silicate - $ZrSiO_4$) (for the most part of size 2-4 micron) is utilized for support as particulates. Zircon is a hard material, its hardness is 7.5 on Mohr's scale and particular gravity is 4.6-4.7. The vital auxiliary unit of zircon is a chain of substituting edge-sharing SiO_4 tetrahedron and ZrO_8 triangular decahedra

Fig 1.3 Zirconia Flour

2 EXPERIMENTAL PROCEDURE

2.1 Methodology

The casting process is going to adopt for the production of the composite. Calculation will use to determine the amount of Fly ash and Zirconium Flour required to prepare keeping Fly ash 3% fix and varying Zirconium flour (2%, 4% & 6%) reinforcements (in the Al matrix) consisting of Fly ash and Zirconium Flour and weight percent respectively The furnace heats to a temperature of 750°C to ensure the alloy melts completely. The fluid compound will then permit to cool in the heater to a semi strong state at a temperature of around 600˚C. The preheated Fly ash and Zirconium Flour is added to the molten alloy at this temperature and stirring of the slurry will be performed manually for 15-20 minutes.

2.2 Equipments Used

Table2. Equipments Used

Sl. No	Equipment's	Specifications
01	Electric arc furnace	Capacity : 6Kg Operating Temp :800°c Power rating :6Kw Heating Element : Al6061+Fly ash+ZrSiO4
02	Optical microscope	Name : Olympus Magnifications : 10X, 25X,50X, 100X
03	Rockwell hardness Tester	Load :10Kg to 100Kg Resolution :0.0001 to 0.1 micron Optical lens : 10X, 25X,50X, 100X
04	Wear test machine (Pin on Disc)	Wear track diameter :50mm Specimen size :Dia 10mm, Length 30mm Max RPM : 2000
05	Mold or Die	Cast Iron
06	Stirrer used in casting	Graphite
07	Computerised Universal Testing Machine	Capacity :10Ton

3. TESTS CONDUCTED

3.1 Tensile Test Procedure

To investigate the mechanical behavior of the composites as per ASTM E9 standards, the computerized uniaxial tensile testing machine of 10 Ton capacity was used. The total length of the specimen is 111mm, gauge length 45mm with gauge diameter 9mm.

Fig 3.1 Tensile test specimen

i. Initially the specimen dimensions such as overall length, gauge length and diameter is measured and is recorded and same is fed in computer as input.
ii. Mark the gauge lengths, which can be used to find the distance between the gauge marks after the failure of specimen and used to calculate the percent elongation.
iii. Before installing the specimen the testing machine is set to zero and then started to load with load rate of 5mm/min.
iv. The tensile load is applied till the specimens fails, later remove the broken specimens and try to fix the fractured ends and measure the distance between the marked gauge lengths.
v. The output values such as Ultimate tensile strength are noted. The test is repeated for other set of specimens.

3.2 Hardness Test Procedure

Hardness is the limit of the material to oppose the surface space. Hardness test helps in understanding the materials imperviousness to the surface entrance and greatest anxiety required cause surface disfigurement. The Rockwell hardness test was led at room temperature.

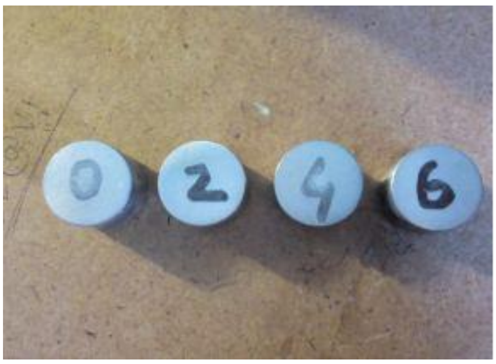

Fig 3.2 Hardness test Specimens

i. Specimen is assured for having parallel and even surface, which is place on the anvil.
ii. A load of 15Kg for 10 seconds was applied on the polished samples using 1/16" red ball indentor.
iii. For each sample three indentation readings were taken and an average of three reading is taken for hardness measurement.
iv. The round indentation which occurs on the specimen after applying load is optically measured to note the indent diameter which is used for hardness calculations.The procedure is repeated for all the specimens of different composition.

3.3 Wear Test Procedure

3.3 Wear test Specimens

i. Before testing the specimens are cleaned and weighed using digital weighing machine and dimensions are measured using Vernier caliper scale.Assure that the testing end of the pein is polished to get smooth and even surface.
ii. Insert the test (pin) into the holder and adjust the specimen polished end to be perpendicular to the disc surface.
iii. The test running time is calculated based on the distance (1000m) to be travelled and speed and the machine is set accordingly. The required load (1Kg, 2Kg and 3Kg)is applied on the loading pan which develops the forces to press the pin against the disc surface.
iv. The disc rotation is started for required rpm. Till the set time when the specimen is undergoing wear the frictional force is recorded for every constant intervals of 30sec and 60sec.
v. After test the pin is cleaned to remove the loose worn particles or debris.
vi. Finally the wearied specimen is measured to note the dimensions which are further used to calculate the wear loss

4. RESULTS AND DISCUSSION

4.1 Tensile Test

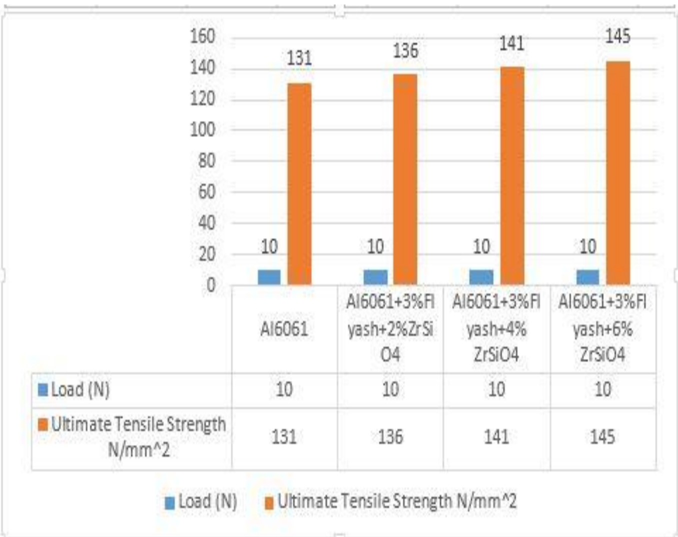

Fig 4.1 Load Vs Ultimate Tensile Strength

There is an increase in tensile strength with increase in reinforcement percentage and with 3wt% of Flyash and 6wt% of Zirconia flour used as a reinforcement has got maximum tensile strength.

4.2 Hardness Test (Rockwell hardness)

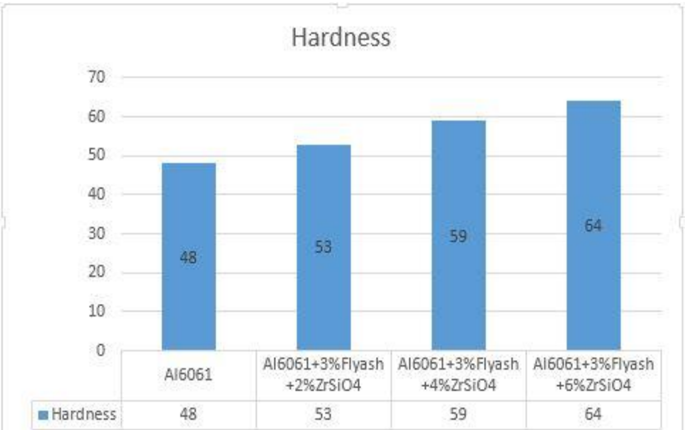

Fig 4.2 Hardness Vs Reinforcement

It is observed that hardness of the composite is increased on reinforcement of Fly ash and Zirconium Flour particles with base Al 6061 alloy. A rise in the hardness of the base metal can be observed that addition of 2wt%, 4wt% and 6wt% of ZrSiO4 with constant 3wt% of fly ash. This hardness is may be due to strong inter molecular bonding between the reinforcement and matrix.

4.3 Wear Test

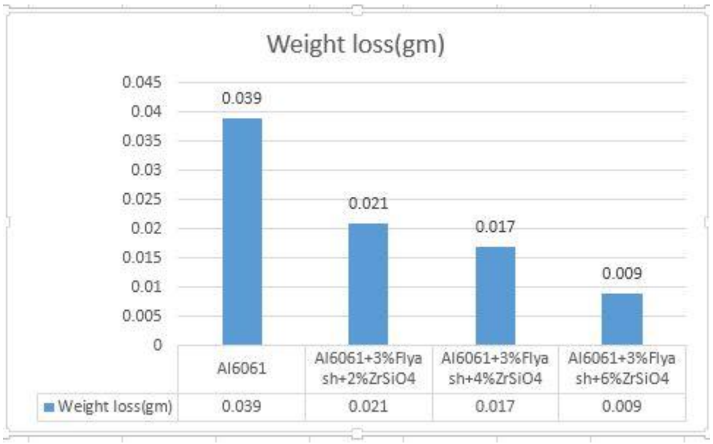

Fig 4.3 Weight Loss at 1Kg load

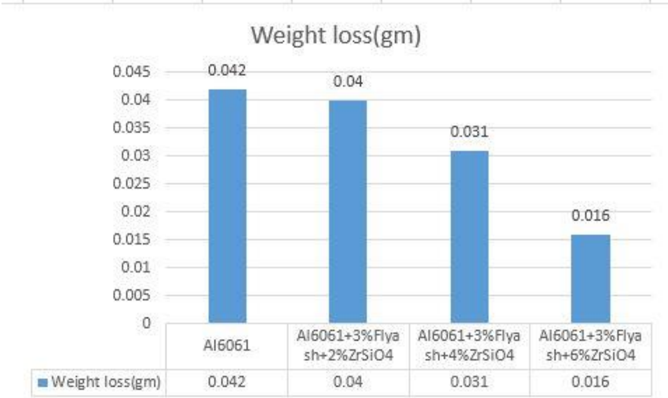

Fig 4.4 Weight Loss at 2Kg load

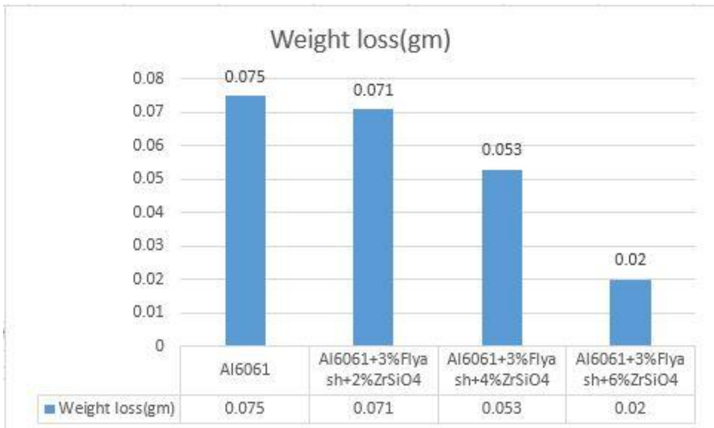

Fig 4.5 Weight Loss at 3Kg load

The wear volume loss is decreased with the addition of Fly ash and Zirconium Flour as particles and it is further decreased with the incorporation of different volume fraction .At the initial phase, little change in volume loss was observed for the composites, as the sliding distances increase more change in the wear was observed. The wear resistance of the Fly ash and Zirconium Flour as particles reinforced composites is increased compared to the unreinforced alloy at all sliding distances. The drastic decrease in volume loss was observed with the addition of reinforcement content. The wear rate is reduces as the addition of 6wt% of Zirconium Flour and 3wt% of fly ash with the Al6061.

5. CONCLUSIONS

I. The Al6061/Fly ash/$ZrSiO_4$ composite is successfully fabricated with different weight fractions of varying $ZrSiO_4$ and keeping constant fly ash using conventional stir casting method.
ii. The Ultimate Tensile strength and hardness was increased.
iii. The wear resistance is improved with 6wt% addition of $ZrSiO_4$ and 3wt% Fly ash with Al6061. The wear rate increased on increasing the speed and load.

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