A study on mechanical properties of Al6061 reinforced with fly ash and red mud

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Abstract - Rare and expensive a century ago, aluminum has since been identified as the most common metal on earth, forming about eight per cent of the earth's crust. The synthesis and characterization of a wide range of Aluminum based composites has continued to generate a lot of interest judging from the large volume of publications in this area of materials science and engineering for the past thirty years. This is due to the versatile applications Al based composites have been successfully utilized in and the huge prospects it has for so many other new applications. to study the influence of the particle size of fly ash and red mud as reinforcement on the aluminum alloy (Al6061) composite and to study its effect on mechanical properties different sizes of fly ash and red mud have been selected in the present study. An attempt is made to the influence of these parameters on the various properties so as to explore it as an interesting and useful engineering material. The reinforcement of Aluminum matrix with the use of fly ash and red mud particles & to study the microstructure properties of the developed composites by Image analyzer. Also to study the mechanical properties of the developed composites.

Key Words: Fly ash, Red mud, tensile test, hardness, microstructure.

1. INTRODUCTION

6061 is a precipitation hardening aluminum, containing magnesium and silicon as its major alloying elements. Originally called "Alloy 61S," it was developed in 1935. It has good mechanical properties and exhibits good weldability. It is one of the most common alloys of aluminum for general purpose use. It is commonly available in pre-tempered grades such as 6061-O (annealed) .6061 aluminum is commonly used in aircraft construction. Its strength-to- weight ratio is very high, making it ideal for large parts that need to be very light, such as the plane's fuselage and wings. Fly ash, also known as "pulverized fuel ash" in the United Kingdom, is a coal combustion product composed of fine particles that are driven out of the boiler with the flue gases. Ash that falls in the bottom of the boiler is called bottom ash. In modern coal-fired power plants, fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys. Together with bottom ash removed from the bottom of the boiler, it is known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amount of silicon dioxide (SiO2) (both amorphous and crystalline), aluminum oxide (Al2O3) and calcium oxide (CaO), the main mineral compounds in coal- bearing rock strata.

Table -1: Chemical composition of Fly Ash.

Constituent	% Composition
Silica (SiO2)	**55**
Aluminum Oxide (Al2O3)	**26**
Ferrous oxide (Fe2O3)	**7**
Calcium Oxide (CaO)	**9**
Magnesium Oxide (MgO)	**2**
Sulfur trioxide(SO3)	**1**

Red mud is a highly alkaline waste product composed mainly of iron oxide that is generated in the industrial production of alumina (aluminum oxide, the principal raw material used in the manufacture of aluminum metal and also widely used in the manufacture of ceramics, abrasives and refractories). Annually, about 77 million tons of the red special waste are produced, causing serious disposal problem in the mining industry. The scale of production makes the waste product an important one, and issues with its storage are reviewed and every opportunity is explored to find uses for it. Over 95% of the alumina produced globally is through the Bayer process; for every ton of alumina produced, approximately 1 to 1.5 tons of bauxite tailings/residue is also produced.

Table 1.2: Chemical composition of Red Mud

Constituent	% Composition
Ferrous oxide (Fe_2O_3)	26.4
Calcium Oxide (CaO)	21.8
Aluminum Oxide (Al_2O_3)	18.9
Silica (SiO_2)	8.52
Titanium dioxide (TiO_2)	7.40
Sodium Oxide (Na_2O)	4.75
Other elements	12.1

2. METHODOLOGY

The fly ash used in this work was obtained from bricks industry.

Fig 1: Fly ash particles

The Red mud used in the work obtained from local area photograph of the red mud is shown in below figure.

Fig 2: Red mud Fly ash particles

Specimen Preparation:

1. The casting process is going to adopt for the production of the composite.

2. Calculation will use to determine the amount of red mud require to prepare 2,4,6,8 wt% reinforcements respectively keeping 4% fly ash constant.

3. Calculation will use to determine the amounts of Aluminum 6061 require and Aluminum 6061 is shown in below Fig 3.

Fig 3: Aluminum 6061. Tests Conducted:

1. Tensile Test: The standard sample shave been prepared (100*30*30 gauge length=40, diameter=8 mm) out of castings.

2. Brinell Hardness Test: Applying a preliminary (or minor) force (load) of 10 N for normal automatically or manually zeroing the penetration measuring instrument.

3. Microstructure: Surface finish is carried out by a sand paper with grades ranging from 220, 400, 600, 800 and 1000. Polished in a rotating polishing disk machine. Also treated with etchant (mixture of HCL+HNO3+Distiled water).

3. Results and Discussion

Table 1 . 3 :The tensile test was conducted for the developed composite. The result shows in the table.

Set s	Composition	Peak load (N)	Breaking load (N)	Ultimate tensile strength (N/sq mm)	Elongation %
1	Al 6061	1529.9	774.8	48.3	21.16
2	Al 6061+ 4% FA + 2% RM	2422.3	9.8	76.5	20.86
3	Al 6061+ 4% FA + 4% RM	2510.6	9.8	79.2	20.31
4	Al 6061+ 4% FA + 6% RM	3275.5	9.8	103.4	9.63
5	Al 6061+ 4% FA + 8% RM	35501	9.8	112.1	7.44

Ultimate tensile strength

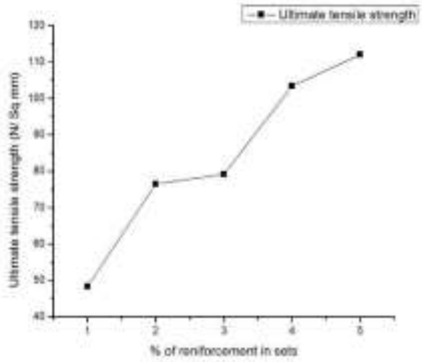

Fig. 3: Variation in Ultimate tensile strength with weight fraction.

Tensile strength of unreinforced Al is 48 N/ Sq mm and this value increases to 112.1 N/ Sq. mm.

Percentage elongation.

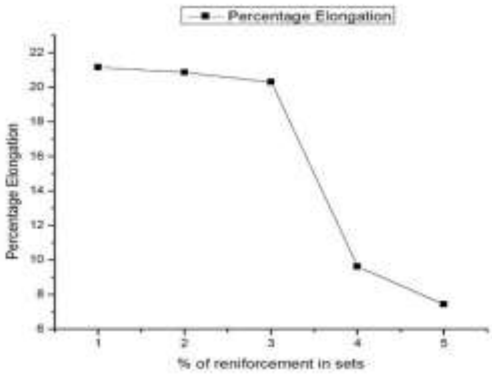

Fig. 4: Variation in Percentage elongation with weight fraction.

Elongation of unreinforced Al6061 is observed as 21.16 %, this value is decreased to 20.86% for set 2, 20.31 % for set 3, 9.63% for set 4 and 7.44% for set 5, composite which is

About 47.97% with a reduction of the unreinforced Al6061 matrix.

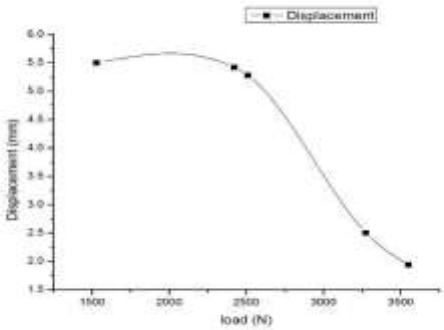

Fig. 5: Variation in Displacement versus Load

From the tensile test initial horizontal tangent is associated with the alignment and gap of the tensile apparatus. It is followed by a linear elastic regime. The final stage of the curve corresponds to brittle fracture. Fracture occurs generally far from the grips and orientation of the fracture surface is perpendicular to the tensile axis. The fracture strength in tension was taken as the maximum stress sustained by the specimen.

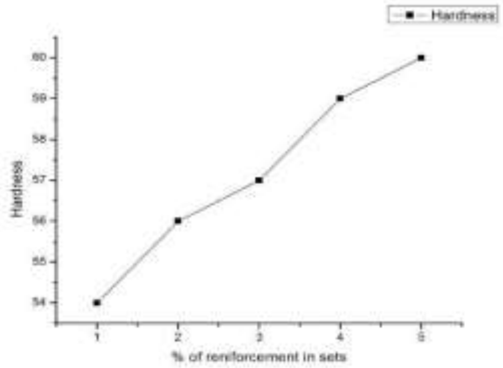

Fig. 6: Variation in Hardness with weight fraction

It is observed that hardness of the composite is increased on reinforcement of Fly ash and Red mud particles with base Al 6061 alloy. A rise in the hardness of the base metal can be observed that addition of set2, set 3, set4 and set5 of reinforcement.

Microstructure study

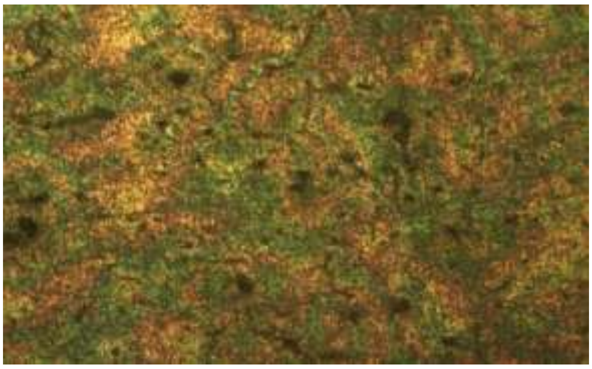

Fig. 7: The microstructure of Al6061 + 0% composite.

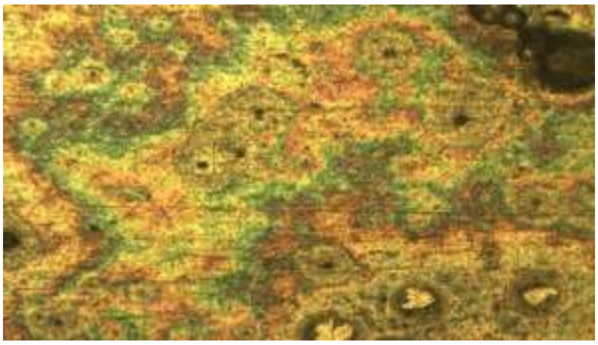

Fig. 8: The microstructure of Al6061 + 2% Fly ash +2% Red mud

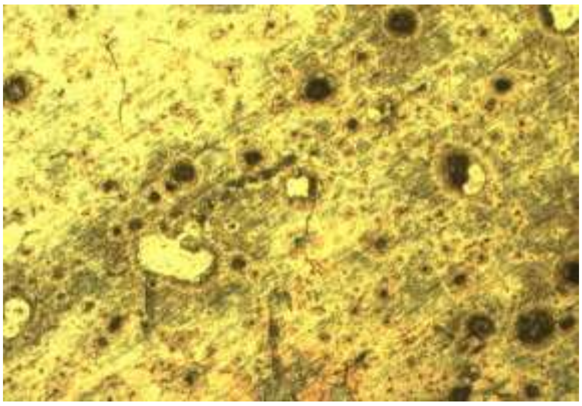

Fig. 9: The microstructure of Al6061 + 2% Fly ash +4% Red mud

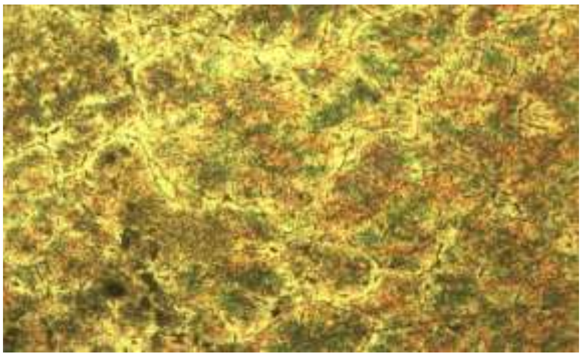

Fig. 10: The microstructure of Al6061 + 2% Fly ash +6% Red mud

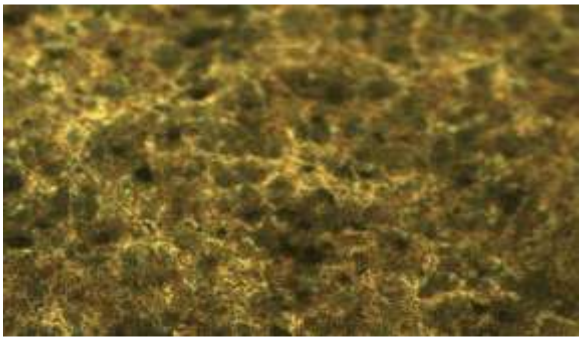

Fig. 11: The microstructure of Al6061 + 2% Fly ash +8% Red mud

Micro structure analysis shows the uniform distribution of red mud and fly ash particles in the aluminum alloy. The microstructure also revealed good retention of red mud and fly ash particles in the matrix. From the Figure 5.8.the fly ash is more as depicted in the form of hollow spheroids. Whereas red mud in the form of flakes. The reinforcements red mud and Fly ash are not uniformly distributed due to improper bonding between reinforcements and matrix alloy. From the image 5.10 the red mud is more in the form of flakes and Fly ash in the hollow spheroids is less. In this case the red mud particles are agglomerated on the sides of the composite and Dominating fly ash particles this is due to the poor wettability.

3. CONCLUSION

The presence of the red mud and fly ash particles in the Alumimium alloy results in a smaller grain size in the cast composites compared to the matrix alloy. The hardness value of the developed composites increased with an increasing percentage of red mud and fly ash particles additions. When the tensile value is taken with respect to the load it increases the displacement linearly with varying percentage of red mud and fly ash particles in addition.

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