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Investigation On Mechanical Properties Of Red Mud And Fly Ash Particulate Reinforced Al6061 Metal Matrix Composite

Sachin Kumar

Advance Material Science and Technology, National Institute of Technology Durgapur, West Bengal, India

P S Ranjan

Prateek B

Kiran V

Mechanical Department, Siddaganga Institute of technology, Tumakuru, Karnataka

Abstract: ***Composite are widely used in modern days, that to Metal Matrix Composite (MMC) for varies application such as aerospace, automobile, industries, etc., Mechanical properties of MMC can be enhanced by adding reinforcement. In this study, Al6061 metal composite were produced by adding Red mud and Fly ash which are main industrial by-products. These specimens were casted with help of stir casting method to study microstructure and mechanical properties. Al6061 is melted at about 800 degree Celsius temperature with help of electric arc furnace. Red mud and fly ash are pre-heated at about 200 degree Celsius to remove moisture contain from it. During stirring to enhance the wetability small quantities of Magnesium (0.2wt% to 0.5wt %) and solid hexachloroethane (C2Cl6) to release all the absorbed gases were added to the melt. Optical micrographs show fairly uniform distribution of Red mud and Fly ash in Aluminium matrix. Composites containing 5%wt Red mud and 5%wt Fly ash showed highest compressive strength(592.67 N/mm2) and 5%wt fly ash and 2.5%red mud depicted highest tensile strength(187.5 N/mm2) compared to that of base material(Al6061 alloy).***

Keywords Al6061, fly ash, red mud, stir casting, compression and tensile strength.

I. INTRODUCTION

Composite material given different direction to explore new material, which can fulfil all needs. They can be used in varies field from automobile to aeronautical field. Composite material is used to fabricate chasse of automobile and outer most body of space shuttle which can sustain a large temperature variation due to its low temperature coefficient property. Composite consist of two main constituent i.e., matrix and reinforcement. Matrix is a monolithic material into which the reinforcement is embedded. The new material may be preferred because they are stronger, lighter and have a low coefficient of thermal expansion; good wear resistance etc., when compared to other materials[1][4]. In most of the application metal matrix composites (MMC) are used due its low cost and ease of fabrication. Metal matrix composites are composed of an element or an alloy matrix in which a second phase is embedded and distributed to achieve some property improvement [8]. They have outstanding benefits due to the combined metallic and non-metallic properties, there by yielding improved physical and chemical properties. Among the various types of MMC's, particulate reinforced composites are the most versatile and economic one. Metal matrix composites are increasingly found in the mobile industry, these materials use a metal such as Aluminium as a matrix, and reinforce with fibres [2].

Matrix is major constitute in composite material so selection of matrix plays important role in enhancement in mechanical properties [2]. Common used matrix materials are Aluminium, Magnesium and Titanium metals and its alloys. Aluminium and its alloys are having unique properties such as high strength to weight ratio, low density, good in tensile strength, corrosion resistance, etc.; hence they have wide range of application in aerospace, auto mobile industry, used

in building ship, submarine. [4]. Main constituents of aluminium alloy is silicon, magnesium, zinc, copper, etc., Aluminium alloy series can be obtained by changing composition of alloying element and from heat treatment. In our present work Al6061 used, silicon and magnesium are major alloying element. Al6061 having good mechanical properties (E-70 N/mm2, hardness number-95, low density-2.7g/cc) [1] [4].

In composite material second main constituent is reinforcement. It plays role in absorbing force acting on composite material. While selecting of reinforcement, consider some critical criteria such as size, shape, structural morphology, etc., commonly used reinforcement in the form of fibres, particulates and whiskers [2].

Due modern industrialisation waste or by-products are produced in large quantity which can be used as reinforcement in Aluminium matrix [3]. Red mud and Fly ash are to main by-product of cement industries, which are having unique properties. Utilizing these waste products as reinforcement can increase mechanical and chemical properties of base alloy [3] [5]. In present, using particulate reinforcement are used with 5-10 micrometre size. Experiment is conducted by varying wt. % of reinforcement (red mud and fly ash) and need achieve uniform distribution in Al6061 matrix, which will affect mechanical properties of matrix [7]. Tensile and compression test are conducted to check mechanical properties of new composite material. If properties of composites are improved, they can be used for wide range of application. Al6061 can be used in manufacturing of automotive components. Al6061 alloy is well-suited to the construction of yachts, motorcycles, bicycle frames, scuba tanks, and camera lenses, fishing reels, electrical fittings, couplings and valves. We can replace Al6061 from above application with new material on which we conducting different testing.

II. EXPERIMENTAL METHOD

A. CASTING

Red mud and Fly ash particle reinforced in Al6061 alloy composites containing 2.5Wt % and 5Wt% of red mud, fly ash separately and another set of composites by mixing of red mud, fly ash(2.5Wt% and 5Wt%) were produced by melt Stirring. The stirring time was maintained between 60-80 seconds. The chemical Composition of the Al6061 alloy matrix was analyzed with the help of Atomic Absorption Spectroscopy (VARIAN) is presented in Table 1 and composition of Red mud and Fly ash are shown in table 2 and table 3 respectively. While stirring to increase the wettability small quantities of Magnesium (.2% to .5%) and solid hexachloroethane (C2Cl6) to release all the absorbed gases were added to the melt. The stirring of the melt was done with the help of a Zirconium coated steel rod to generate parabolic vortex. A spindle speed of 220rpm and stirring time 5- 6min were adopted. Formed molten composite was added to preheated metallic mould having dimension 125mm height and 15mm diameter.

B. MICROSTRUCTURAL STUDY

Microstructural study will gives information about uniform distribution of reinforcement in matrix. Uniform distribution will help to enhance the mechanical properties of material. The prepared composites were subjected to micro structural characterization using OPTICAL MICROSCOPE to identify morphology and distribution of red mud and fly ash particles in Al6061 matrix.

Components	% Wt.
Al	Balance
Mg	0.85-1.2
Si	0.46-0.82
Fe Max.	0.75
Cu	0.15-0.23
Zn Max.	0.24
Ti Max.	0.16
MN Max.	0.13
Cr	0.03-0.33
Others	0.07

Table 1: Composition of Al-6061

Components	% Wt.
Al2O3	21-23
SiO2	42-44
Fe2O3	13-14
CaO	1.6-2.5
Na2O	1.2-2.5
TiO2	4-7

Table 2: Composition of Red mud

Components	% Wt.
Al2O3	60.07
SiO2	17.65
MgO	1.15
SO3	1.65
Na2O3	0.32
K2O	0.05
LOI	2.77

Table 3: Composition of Fly Ash

Figure 1: Melting process

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Figure 2: Molding process

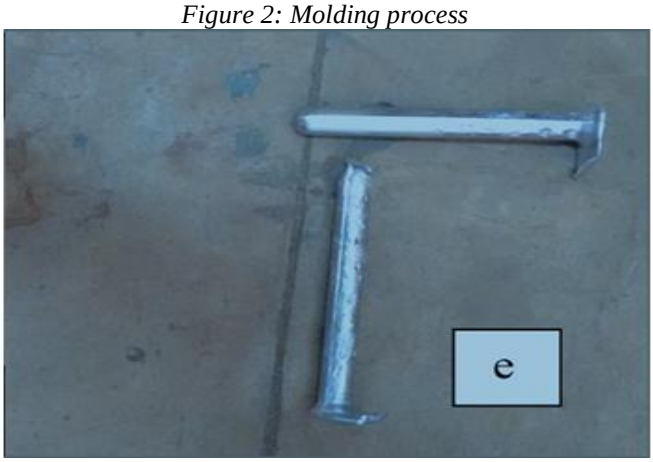

Figure 3: Final Cast Product

a. STEPS INVOLVED IN THE MICRO STRUCTURE ANALYSIS

- ✓ Grinding-It is process of removal of material, preparing test specimen with appropriate dimension. It will produce rough surfaces.
- ✓ Lapping- It is the removal of material to produce a smooth unpolished surface. It is used to produce dimensionally accurate specimen to a high tolerance. The lapping plate will rotate at a low speed (80rpm) and an abrasive particle (5 to 20 microns) is used.
- ✓ Polishing- It is removal of material to produce a scratch free surface using (3 microns) abrasive particles. Polishing with abrasive produces excellent results.

C. TENSILE AND COMPRESSION TEST

Composite material were prepared by varying composition of red mud and fly ash(0%wt to 5%wt) to analyze mechanical properties such as tensile and compression test. The test specimens were prepared as per ASTM E8-15a for tensile test and ASTM E9 for compression test.

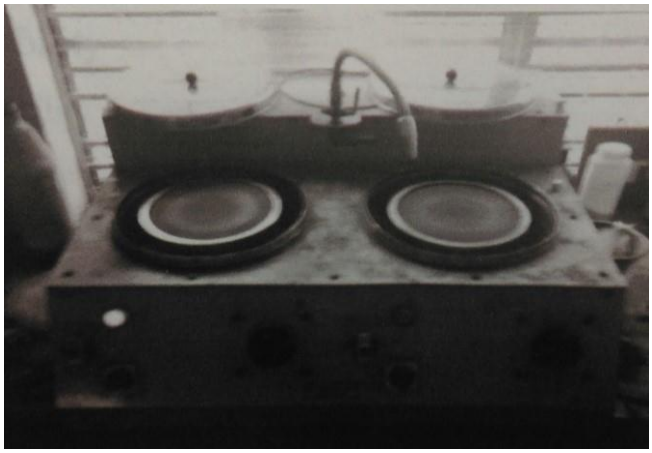

Figure 4: Polishing Machine

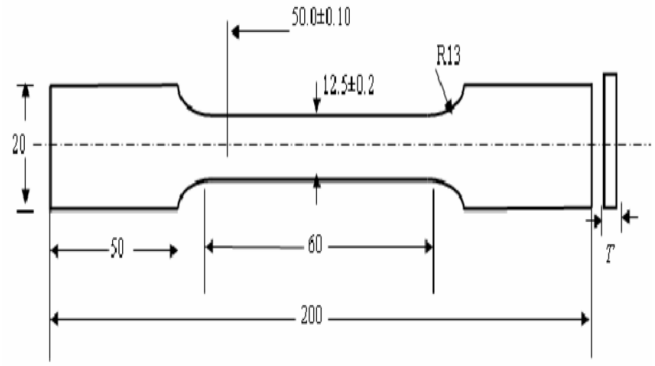

Figure 5: Specimen dimension in [mm] used for tensile test

III. RESULT AND DISCUSSION

A. MICROSTRUCTURE ANALYSIS

Composite specimen was observed under optical microscope, gives a proper and uniform distribution of reinforcement in matrix Al6061 (fig 6). Fig 7, 8 and 9 represents the mixture of red mud and fly ash distribution in matrix.

Figure 6: OM micrograph for Al6061

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Figure 7: OM micrograph for Al6061+ 5% Red mud+ 5% Fly ash

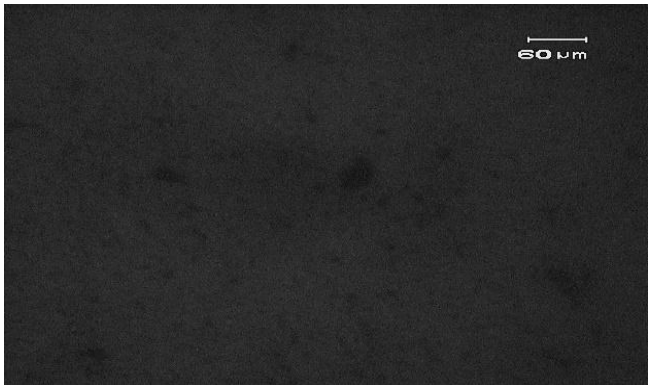


Figure 8: OM micrograph for Al6061 + 2.5% Red mud

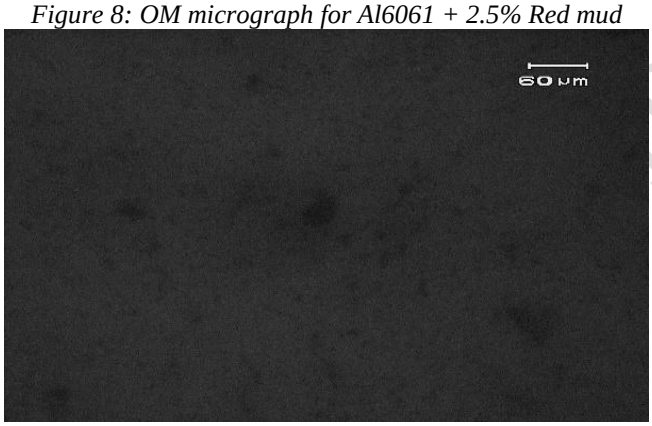


Figure 9 : OM micrograph for Al6061 + 2.5% Fly ash

B. MECHANICAL PROPERTIES

COMPRESSION TEST: Compression test will gives the maximum stress a material can sustain over a period under a load (constant or progressive) is determined. Fig 10 will gives variation of compression strength with varying weight % (2.5% wt. and 5%wt) of red mud and fly ash. Fig 11 gives variation of compression strength by adding mixer of red mud and fly ash. From fig 10 and 11, it is clear that maximum compression strength(592.67 N/mm2) is obtained by adding 5%wt fly ash+ 5%wt red mud.

TENSILE TEST: Test is conducted in digital universal testing machine Fig 13 will depict changes of ultimate tensile strength with varying weight % (2.5%wt and 5%wt) of red mud and fly ash. Fig 14 shows variation of ultimate tensile strength due to mixture of reinforcements (red mud + fly ash). From fig 13 and 14, it clearly indicates that, maximum tensile strength(187.56 N/mm2) is obtained by adding 5%wt fly ash and 2.5%wt red mud but for 5%wt fly ash and red mud will gives average tensile strength(172.99 N/mm2).

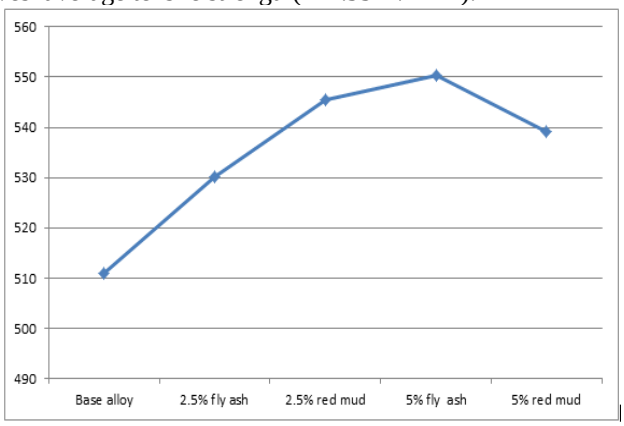


Figure 10: Variation of compression strength with only red mud and fly ash

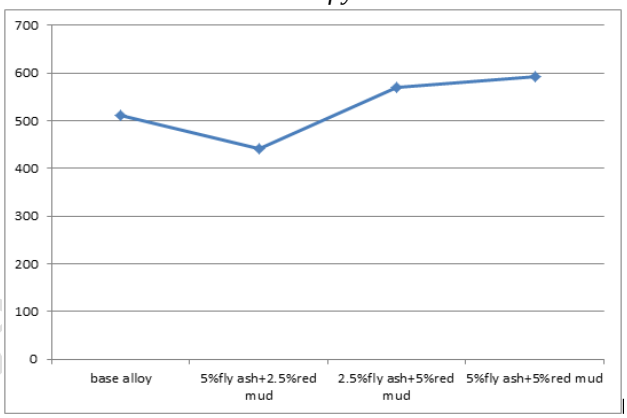


Figure 11: Variation of compression strength with mixer of red mud and fly ash

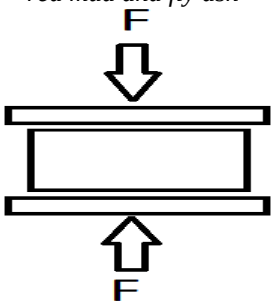


Figure 12: Compression test

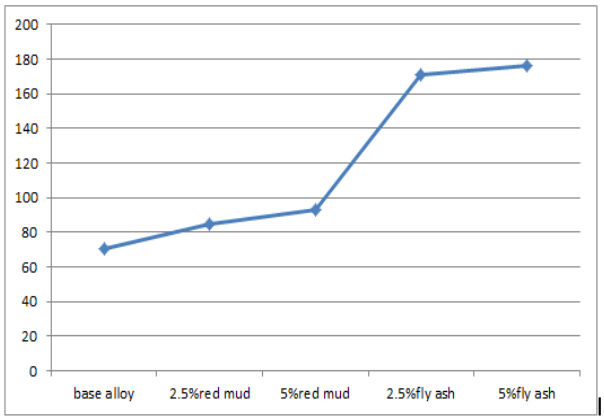


Figure 13: Variation of Tensile strength with only red mud and fly ash

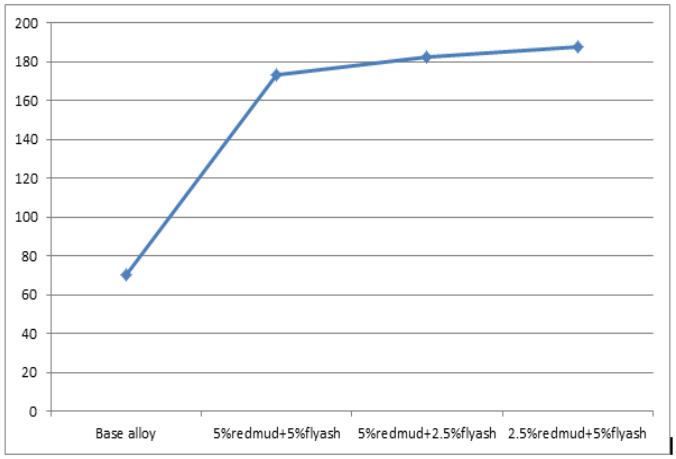
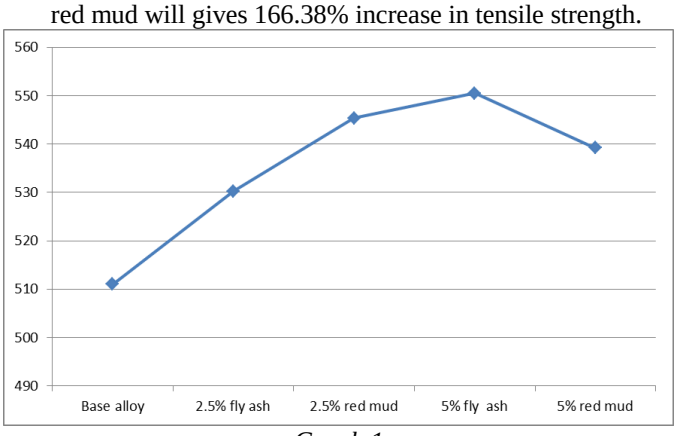


Figure 14: Variation of tension strength with mixer of red mud and fly ash

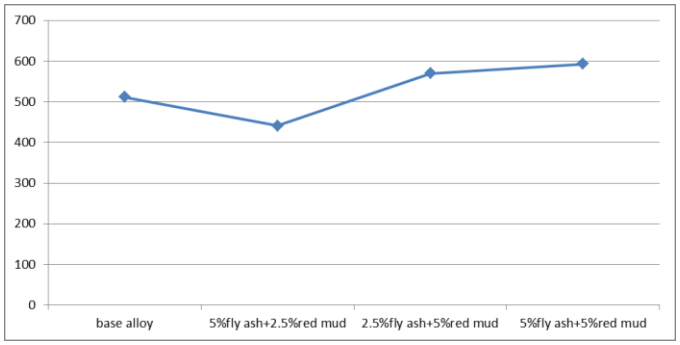
IV. CONCLUSION

Composite specimens are produced by stir casting method, microstructural and mechanical properties were analysed.

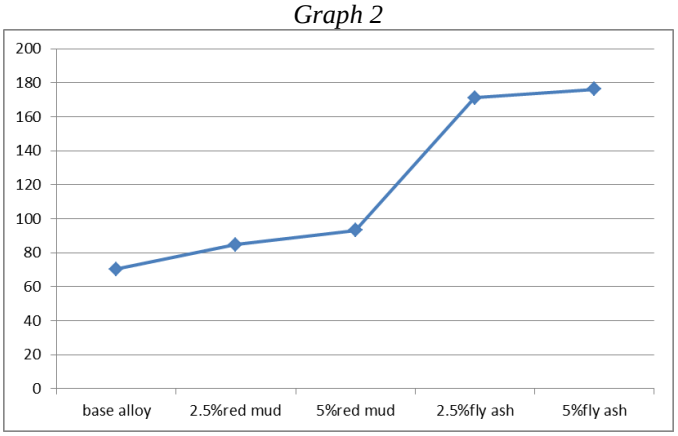
- ✓ Composite specimen was produced successfully by stir casting method with fairly uniform distribution of reinforcement in metal matrix.
- ✓ By adding 5% fly ash, 7.66% increase in compression strength and for 5% of red mud it is 5.66% improvement in compression strength when compared to base alloy (Al6061).
- ✓ From mixer of reinforcement i.e., 5%wt fly ash+5%wt red mud will gives 15.92% increase in compression strength.
- ✓ By adding 5% of red mud, 32.46% increase in ultimate tensile strength and for 5% of fly ash it is 150.34% improvement in ultimate tensile strength when compared to base alloy (Al6061).
- ✓ From mixer of reinforcement i.e., 5%wt fly ash+2.5%wt red mud will gives 166.38% increase in tensile strength.



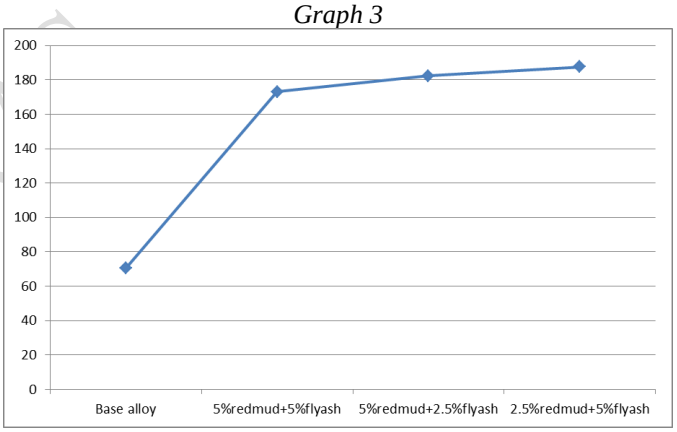
Graph 1



Graph 2



Graph 3



Graph 4

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