Evaluation of Mechanical Properties of Al 7075 Alloy, Flyash, SiC and Redmud Reinforced Metal Matrix Composites

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Abstract— Aluminium alloys are widely used in aerospace automobile industries due to their low density and good mechanical properties, better corrosion resistance and wear, low thermal coefficient of expansion as compared to convention metals and alloys. The main aim involved in the present work is focused on study of mechanical properties of Al7075 alloy composite having varying weight percentages of 3% - 6% of Silicon Carbide, Fly ash and Red mud were fabricated by liquid metallurgy (Stir Casting) method. The casted composite specimens were machined as per BS: 18: 1962 test standards. The result obtained reveals that tensile strength, impact strength and wear resistance is higher in Al7075-SiC-Redmud samples when compared to Al7075-SiC-Flyash samples.

Key words: Fly ash, Sic, Red mud, Al7075 alloy composite, mechanical properties, and stir casting.

I. Introduction

Aluminum alloys are broadly used as a main matrix element in composite materials. Composite material consists of two or more constituents. One constituent is called matrix phase and other is called reinforcing phase. Reinforcing phase is embedded in the matrix to give the desired characteristic.

MMC's are made by dispersing a reinforcing material into a metal matrix. As the name implies, for metal matrix composites, the matrix is a ductile metal. These materials may be utilized at higher temperatures than their base metal counter parts, further more; the reinforcement may improve specific stiffness, specific strength, abrasion resistance, creep resistance, thermal conductivity and dimensional stability.

7075 is an aluminium alloy with Zinc as the primary alloying element. It is strong, with strength comparable to many steels and has good fatigue strength and average machinability, but has less resistance to corrosion than many other Al alloy. Due to its strength, high density, thermal properties and its ability to be highly polished, 7075Al is widely used in mold tool manufacture. Al 7075 remains the baseline with a good balance of properties required for aerospace applications and it is often used in transport applications, including marine, automotive and aviation, due to their high strength-to-density ratio.

Silicon carbide was originally produced by high temperature electrochemical reaction of sand and carbon, it is a compound of silicon and carbon with a chemical formula SiC. The material has been developed into a high quality technical grade ceramic with very good mechanical properties. It is used in abrasives, refractory, ceramics and numerous high performance applications.

Fly ash, also known Flue-ash, is one of the residues generated in combustion, and comprises the fine particle that rise with flue gases. Fly ash particles are almost spherical in shape, allowing them to flow and blend freely in mixtures. Fly ash is one of the most inexpensive and low density reinforcement available in large quantities as waste product during combustion of coal in thermal power plants as well as in brick factory and rice mills.

Red mud emerges as the waste material during the production of alumina from bauxite in Bayer's process. The red color is caused by the oxidized iron present, which can make up to 60% of the mass of the red mud. It comprises oxides of iron, aluminium, titanium and silica along with some other minor constituents.

Rohathgi P.K [1] reported, as we increase the amount of fly ash percentages the hardness value increased in aluminum fly ash composites and similarly tensile strength, elastic modulus were found to increase with increase in pertentage (3-10%) of Fly ash. P. Shanmughsundram, R. Subramanium, G Prabhu [2] reported that, tensile began to drop when flyash exceeds 15wt%, hardness and compressive strengths of composites began to decrease above 20wt%, while density of the composite decreased with increasing fly ash reinforcement. Deepak Singla, and S R Mediratta [3] reported that, with increase in value of fly ash, toughness, hardness and tensile strength was increased compared to the base metal and the density got decreased, so these composites can be used in automobile and space industries due to their light weight.

II. Experimental Details

A. Material Preparation

The present investigation was carried out on 7075 Al alloy composition as shown in Table1. The material was cast in the form of round cylindrical rods of diameter 15mmX 125mm in length by adding SiC, Fly ash and Red mud as reinforcements by various weight percentages. The cast rods were rapidly cooled to room temperature by knocking them out, 5mins after casting. Table 2 shows the composition of Fly ash.

B. Specimen Preparation

The test specimens were prepared by machining from the cylindrical bar castings. The samples for tensile test, each specimen having 10mm dia X 50mm gauge length in size. The specimen for impact testing the samples for Charpy test 10mm X55mm length with 2mm V- notch at the centre. For wear test the specimens with 8mm dia X 22mm length were prepared.

III. Results And Discussion

A. Tensile Testing.

The fundamental material science testing, in which a sample is subjected to uniaxial tension until failure. The properties that are directly measured via tensile test are maximum elongation, ultimate tensile test and reduction in area. Al7075 + 6 % SiC + 6 % Flyash and

Al7075+3%SiC+6%Redmud resulted in higher tensile strength.

B. Impact Testing.

The Charpy impact test also known as Charpy V-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by material during fracture. This absorbed energy is a measure of a given material toughness. Al7075+6%SiC+3%Flyash and Al7075+6%SiC+3%Redmud resulted in higher impact strength

C. Wear Test.

Wear is a process of material removal phenomena. The prepared 7075Al alloy with varying weight percentage of (SiC & Fly ash) and (SiC & Red mud) composites were subjected to wear test under dry sliding condition. The test was conducted on 8mm dia and 22mm long cylindrical specimen. The wear tests were carried out at room temperature for 5mins on the rotating disc, made of EN 32 steel disc.

The test parameters used were as follows;

- Track dia: 60mm
- Speed: 500 rpm
- Load: 30 and Time: 5mins

IV. FIGURES AND TABLES

components	Weight (%)
Si	0.2
Fe	0.3
Cu	1.6
Mn	0.1
Mg	2.5
Zn	5.5
Cr	0.22
Ti	0.1

Table. 1: Table1. Chemical composition of Al7075 in (Wt %)

Components	Weight %
SiO_2	44.8
Al_2O_3	22.2
Fe_2O_3	24
MgO	0.9
CaO	1.8
TiO_2	0.8
K_2O	2.4
Na_2O	0.9
SO_3	1.4
Balance= Oxides of other trace elements	

Table. 2: Chemical composition of Fly ash

Constituents	%	Constituents	%
Na	5.20	Na_2O	7.01
Al	7.67	Al_2O_3	14.49
Si	3.22	SiO_2	6.89
Ca	3.67	CaO	5.13
Ti	12.37	TiO_2	20.63
Fe	30.70	Fe_2O_3	39.49
Cu	2.94	CuO	3.68
Zn	2.14	ZnO	2.68
O	32.09	Total	100
Total	100		

Table. 3: Chemical composition of Red mud in element and compound form

Sample	Composition	Tensile strength N/mm^2
F1	Al7075+3%SiC+3%Flyash	130.881
F2	Al7075+3%SiC+6%Flyash	108.087
F3	Al7075+6%SiC+3%Flyash	110.113
F4	Al7075+6%SiC+6%Flyash	132.295

Table. 4: Results of Tensile test for Fly ash

Sample	Composition	Tensile strength N/mm^2
R1	Al7075+3%SiC+3%Redmud	143.423
R2	Al7075+3%SiC+6%Redmud	150.864
R3	Al7075+6%SiC+3%Redmud	54.455
R4	Al7075+6%SiC+6%Redmud	132.461

Table. 5: Results of Tensile test for Red mud

Sample	Composition	Energy Absorbed kg-m
F1	Al7075+3%SiC+3%Flyash	19.85
F2	Al7075+3%SiC+6%Flyash	18.9
F3	Al7075+6%SiC+3%Flyash	21.3
F4	Al7075+6%SiC+6%Flyash	19.75

Table. 6: Results of Impact test for Flyash

Sample	Composition	Energy Absorbed kg-m
R1	Al7075+3%SiC+3%Redmud	20.35
R2	Al7075+3%SiC+6%Redmud	17.2
R3	Al7075+6%SiC+3%Redmud	24.1
R4	Al7075+6%SiC+6%Redmud	20.4

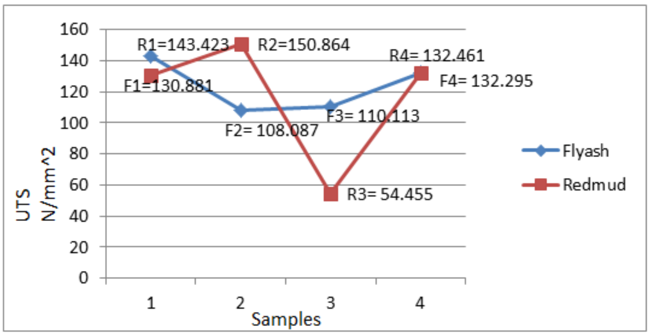
Table. 7: Results of Impact test for Red mud

Sample	Composition	Wear in m m	Wear rate in mm^3/m	Wear resistance m/ mm^3
F1	Al7075+3%SiC+3% Flyash	106.61	11.371X 10^{-3}	87.943
F2	Al7075+3%SiC+6% Flyash	418.35	44.619X 10^{-3}	22.412
F3	Al7075+6%SiC+3% Flyash	213.27	22.741X 10^{-3}	43.973
F4	Al7075+6%SiC+6% Flyash	111.39	11.872X 10^{-3}	84.232

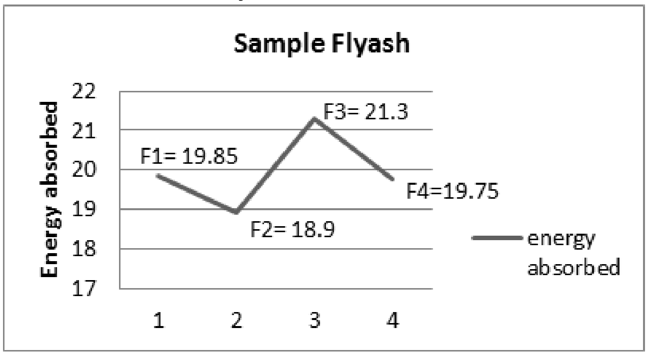
Table. 8: Shows the result of wear rate and wear resistance for Fly ash

Sample	Composition	Wear in m m	Wear rate in mm^3/m	Wear resistance in m/ mm^3
R1	Al7075+3%SiC+3%Redmud	142.66	15.211X1 0^{-3}	65.742
R2	Al7075+3%SiC+6%Redmud	110.38	11.765X1 0^{-3}	84.998
R3	Al7075+6%SiC+3%Redmud	232.75	24.821X1 0^{-3}	40.288
R4	Al7075+6%SiC+6%Redmud	171.67	18.304X1 0^{-3}	54.633

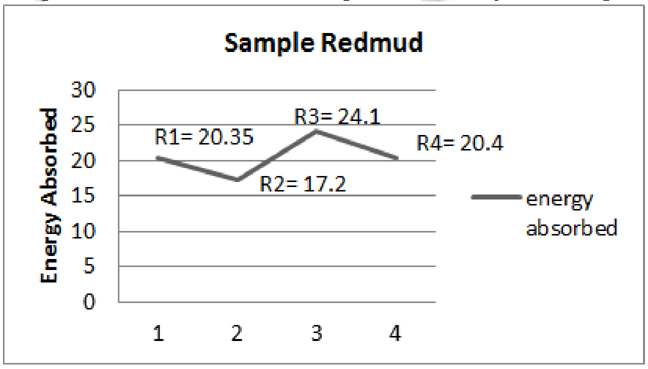
Table. 9: Shows the result of wear rate and wear resistance for Red mud



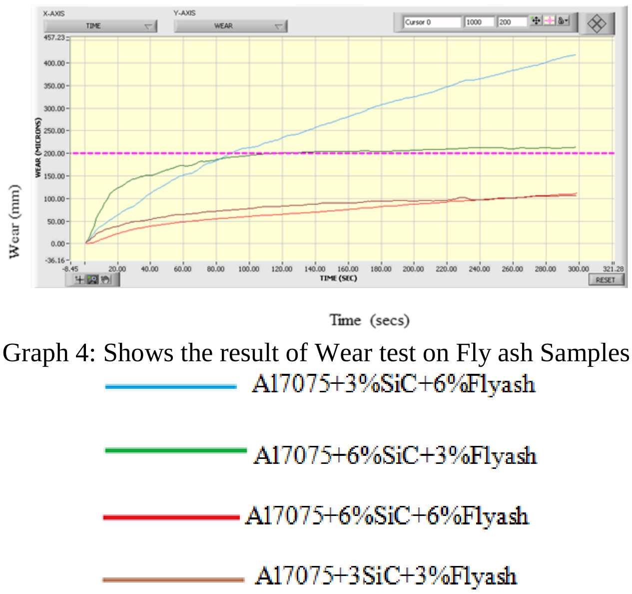
Graph 1: Shows the effect of weight fraction of Al7075+SiC+Flyash and Al7075+SiC+Redmud



Graph 2: Shows the result of Impact test on Fly ash Samples



Graph 3: Shows the result of Impact test on Red mud Samples



Graph 4: Shows the result of Wear test on Fly ash Samples

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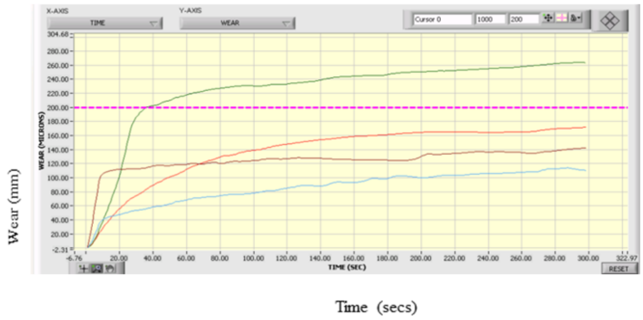
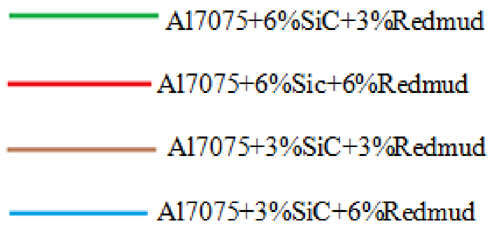


Graph 5: Shows the result of Wear test on the Red mud Samples



V. CONCLUSION

From the experiments conducted to study the effects of adding various volumes fractions of Sic & Fly ash, Sic & Red mud, following conclusions can be drawn.

- Composite material 7075Al alloy reinforced with (SiC & Fly ash) and (SiC & Red mud) was successfully casted by stir casting method.
- The tensile strength in Al7075-SiC-Flyash samples, is found to increase by maintaining the constant percentage of SiC and Fly ash. In Al7075-SiC-redmud samples, increase in the red mud content increases the tensile strength. Higher tensile strength was observed in Al7075-SiC-Redmud composite than Al7075-SiC-Flyash.
- The impact strength increases in Al7075-SiC-Flyash and Al7075-SiC-Redmud, with increase in the SiC weight content while decreases with increase in Fly ash and red mud content respectively. Higher impact strength was observed in Red mud samples than Fly ash samples.
- The wear resistance of the composite Al7075-SiC-Flyash, is found to be higher by maintaining the constant weight percentages of SiC and Fly ash while it decreases by increasing the weight percentage of Fly ash. In Al7075-SiC-Redmud, wear resistance increases with increase in Red mud content.

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