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Charecterization of Al-Redmud Composite using Stir Casting method

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Abstract: Aluminium mainly used in the applications of aerospace and aeronautic industries because of its good mechanical properties. The main aim of all composite materials is to reduce the cost. In this paper the mechanical properties like tensile strength, wear resistance and microstructure are characterised by using aluminium reinforced with Red mud and weight fraction (3% 6% 9%). The aim is to reduce the cost of production MMCs. In order achieve the required aim stir casting method is selected. An obtained result concludes that by adding redmud increases the properties like tensile strength and wear resistance and the selected method is quite successful. Tensile strength is optimum for Al-6%Redmud and wear resistance is optimum for Al-3%Redmud.

Keywords: Al6061, stir casting, mechanical properties and Redmud

I. INTRODUCTION

Composite material is a material which is combined form of two or more material, in which the reinforcement material is embedded in to matrix. Matrix is capable to hold reinforcement to posses required shape and on other side reinforcement improves the mechanical characters of the matrix like stiffness, tensile strength, wear resistance, toughness. Composite materials are divided mainly as MMC, PMS and CMC.

Aluminium 6061 is developed in 1935 and is the most available aluminium alloys for commercial use [1]. This contains the aluminium, magnesium and silicon. This is having properties like, structural strength and toughness, surface finish, improved corrosion resistance to atmosphere and sea water. Aluminium6061 mainly used as construction like manufacturing of aircraft and automotive components.

Red mud emerges as the waste material during the production of alumina from bauxite in Bayer's process. The colour is caused mainly by oxidised iron present in it, and it also contains the materials like oxides of iron, aluminium, titanium and silica along with some other minor constituents [2]. During the production of alumina red mud is generated as waste, this waste material increasing in throughout in the world. The use of red mud mainly to improve value of materials like titanium, vanadium and zinc. The main aim to introduce red med in to aluminium is to achieve increased properties like wear, tensile, hardness of the base metal aluminium with low cost of reinforcement red med[3]. This process is achieved by using stir casting method in which the reinforcement metal (red mud) combined with matrix. By this we can achieve improved properties of aluminium6061 like yield strength and tensile strength, wear resistance, hardness, toughness, thermal shock resistance.

II. EXPERIMENTAL DETAILS

A. Material Composition

Aluminium6061 contains aluminum, magnesium and silicon which are having good mechanical properties.

The chemical composition of Aluminum 6061

Element	Al	Cr	Cu	Fe	Mg	Mn	Si	Tn	Zn	Other
Wt%	Balance	0.04	0.15	0.2	0.8	0.15	0.4	0.15	0.25	0.15

Red mud emerges as the waste material during the production of alumina from bauxite in Bayer's process. It contains materials like oxides of iron, aluminum, titanium and silica along with some other minor constituents.

B. Stir Casting

In order to prepare the metal matrix of composite, the base metal (aluminium6061) and reinforcement material (red mud) along with weight percentage (3%, 6%, and 9%) used.

Stir casting set-up mainly consist of furnace and the stainless steel stirrer which is connected to variable speed rotor as shown in below fig. Initially the base metal is placed in crucible and heated to more than 800 °c in furnace. Once the solid metal turned to molten metal it took out of furnace and placed below the stirrer, the variable rotor started certain rpm mean while the reinforcement material added according required weight percentage ratio, then the mixed molten metal is poured to required shape and sized moulds, and allowed to solidify. In order to get the required properties of MMC, must need a uniform distribution of reinforcement metal in matrix and the between these substances wettability and bonding is optimised and the levels of porosity is also minimised.

Fig.1. stir casting setup

C. Tensile Test

The tensile test carried out by making use of universal testing machine (UTM) at room temperature. The specimen is made with aluminium 6061 as base metal and various weight percentage (3%, 6%, 9%) of red mud as reinforcement material using stir casting method. the raw specimen machined in to required shape and size (gauge length-22mm, filet-2mm, gripper length-40mm both side and total length of the specimen 106mm) according to ASTM E8 standard. Starting the UTM machine is adjusted to required load range and the specimen is fit in to the both jaws and tightened, next machine is switched on to tensile mode and gradually load is applied. The load is applied gradually up to ultimate load at the point load drops and neck formation starts and with the increase in load specimen breaks which indicates the breaking point, after this load specimen breaks and the final value and graphs plotted.

D. Wear Charecterization

Wear is the mechanical property which defines as the removal of material due to the rubbing action with other material. Initially the specimen is tuned in order to get the required shape and size (8mm-diametre and length 30mm), the test is carried out using pin on disc machine. The procedure as follows: Initially the disc is cleaned in order to avoid the dust deposits on the surface of the disc, initially the specimen mass is noted and fixed in to chuck using chuck key. Set the speed, time, load (1, 2, 3, 4kg) then brings the specimen in to contact with disc then machine is switched on then noted down the friction force correspondingly. Once the time ends machine need to switch off and note down the final mass of the specimen, by taking difference between final and initial wear rate will be calculated.

E. Microstructure Studeis

The raw material is reduced to 12mm height and 12mm diameter in order to get the required shape and size for the test. Initially the specimen one side face is filed and then face is polished using polish papers of grit size 220,400,600,800 and 1000, then it is polished on belt polisher with use of water and Al2O3 on polishing cloth. Water and Al2O3 added for every 30-60 sec in order to avoid the generation heat due to the friction between polishing cloth and material face. Once the fine surface is obtained without any scratches, then the specimen is observed on optical microscope in order to obtain the microstructure. This test gives the clear idea about distribution of reinforcement material grain boundaries and size, morphology and microstructure.

III. RESULTS AND DISCUSION

A. Tensile test

The tensile test is conducted at room temperature for the weight percentage of reinforcement material (Redmud). The following results were obtained as showed in table number 1.

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Table.1. Results of Tensile test for Red mud

Sample number	Composition	Tensile strength N/mm2
1	Al6061+0%Redmud	73.22
2	Al6061+3%Redmud	129.82
3	Al6061+6%Redmud	165.90
4	Al6061+9%Redmud	135.83

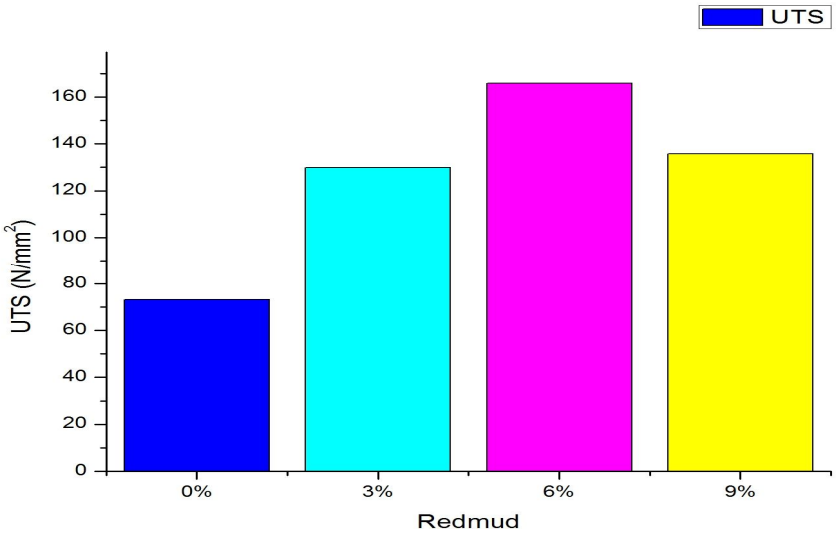

Fig.2. UTS Vs Redmud Composition

From above data it is clear that by adding redmud as reinforcement material the tensile strength of the Al6061 increases. Al6061+6%Redmud posses the high tensile strength from result we can also observe that adding more percentage of redmud decreases the tensile strength. By comparing 6% and 9% redmud, the Al6061+6%Redmud has higher tensile strength.

B. Wear Test

The wear rate is calculated by taking difference between initial and final mass of the test specimen. As the increase velocity and load the wear rate increases, from graphs it is found that 3% Al-Redmud MMCs posses lower wear rate compared to 0%, 6% and 9% Al-Redmud MMCs. All compositions showing lesser wear rate compared to 0% Al-Redmud, and 9% Al-Redmud possessing wear rate nearly to 0%,. From the calculated data it is clear that in order to have low wear rate for different load and speed 3% Al-Remud MMCs is good than 6 and 9%. The following graphs show the wear rate with respect to different load.

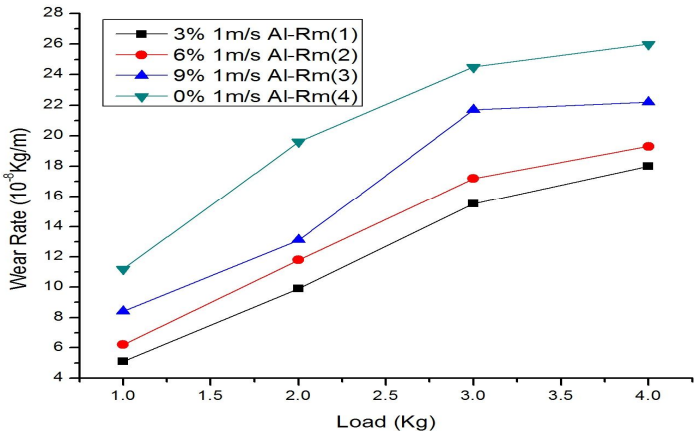

Fig.3. Wear Rate Vs Load at 1m/s Velocity

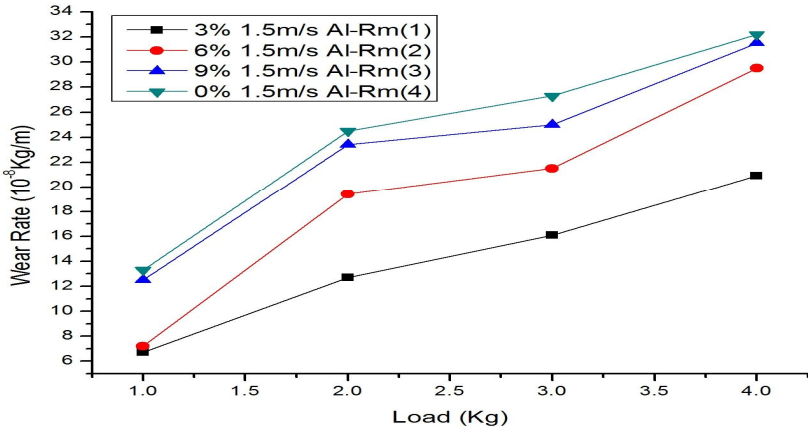

Fig.4. Wear Rate Vs Load at 1.5m/s Velocity

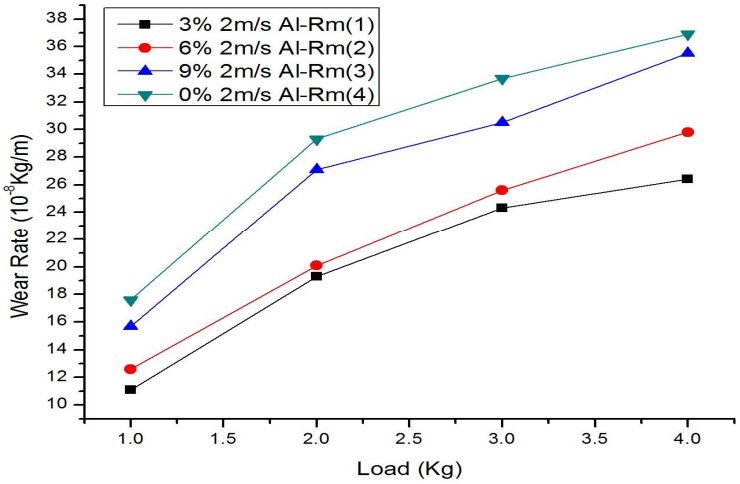

Fig.5. Wear Rate Vs Load at 2m/s Velocity

F. Microstructure

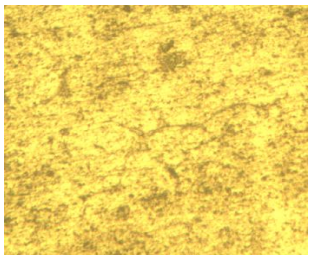

Fig.6. 0% Al-Redmud

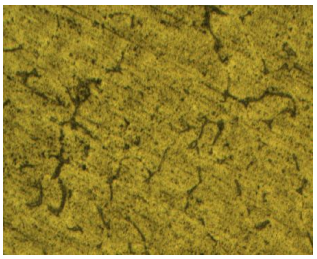

Fig.7. 3% Al-Redmud

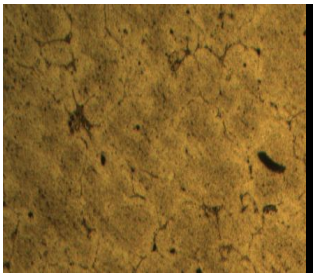

Fig.8. 6% Al-Redmud

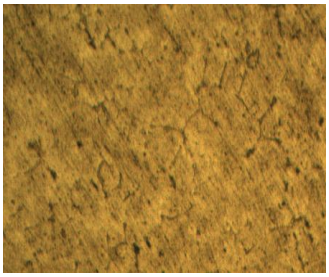

Fig.9. 9% Al-Redmud

The above figures (6, 7, 8 and 9) show the microstructure of casting. We can see the distribution, grain boundaries and structure of reinforcement material in to the base metal. Which indicates the Casting was done successfully.

IV. CONCLUSIONS

A. The adopted method (stir casting) in order to prepare the aluminium based MMCs were successful and achieved uniform distribution of reinforcement material (Redmud) in to the aluminium.

B. The wear rate it is observed that, with increase in weight percentage of Redmud increases the wear rate. It is found that Al-3%Redmud shows very less wear rate compared to 6 and 9% Redmud.

C. The tensile strength found with increase in weight percentage of Redmud, it is found that tensile strength increased with increase in redmud percentage i.e. up to Al-6%Redmud the tensile strength increased and Al-9%Redmud decreased compared to 6%. Al-6%Redmud shows the higher tensile strength.

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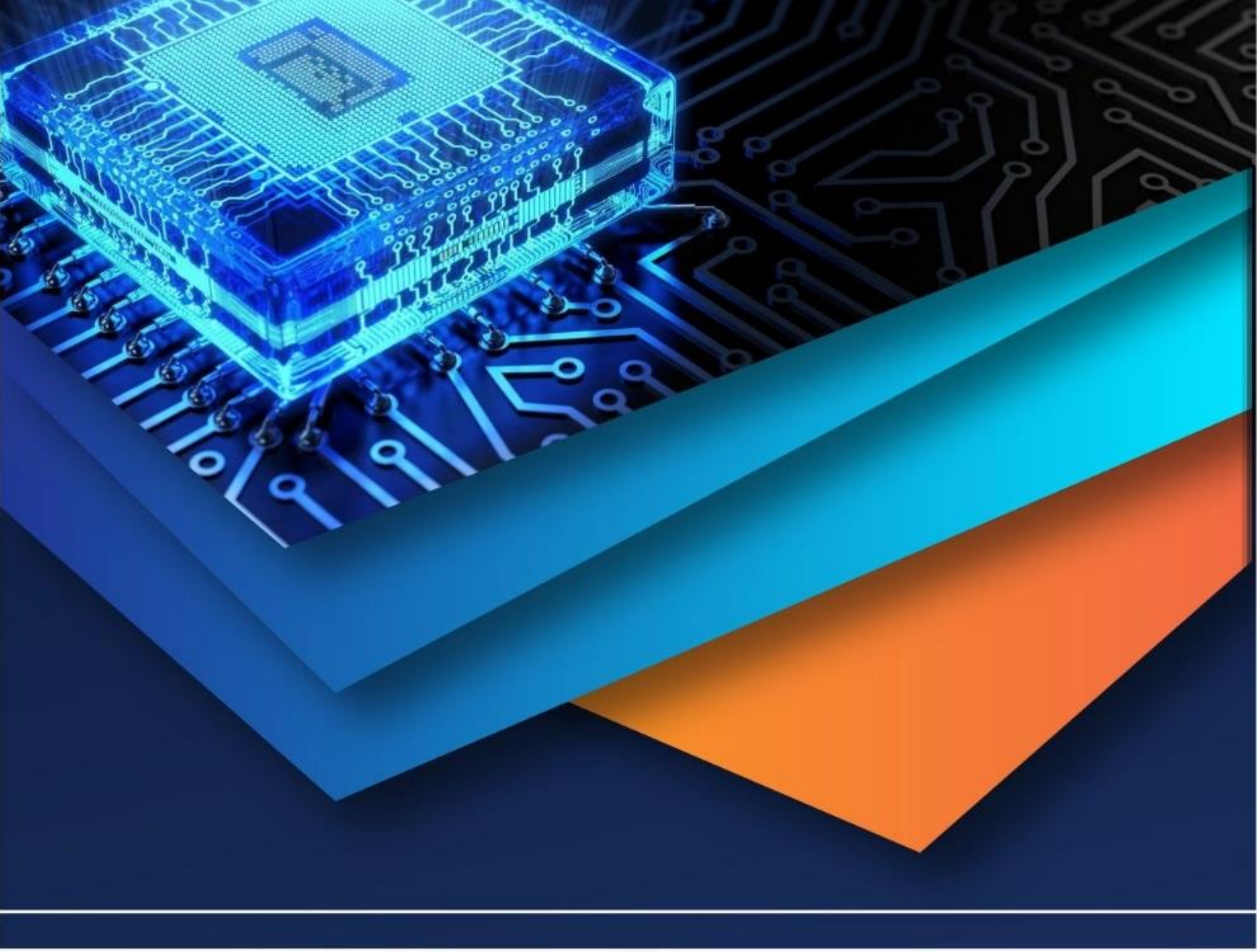

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