MECHANICAL BEHAVIOR OF RED MUD REINFORCED ALUMINUM METAL MATRIX COMPOSITES

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Abstract*—This paper investigates the mechanical behavior of Metal Matrix Composites (MMCs) prepared using Al7075 alloy as matrix and Red mud as reinforcement particle. Two step stir casting process is used to fabricate the composites by varying volume fractions of Red mud (5%, 10% and 15% volume fractions). The 10 Vol. % red mud aluminum matrix composites showed the maximum tensile strength of 215MPa. The maximum tensile strength increased by 40 MPa .Vickers Micro Hardness tests are performed and the hardness values vary from HV145 to HV177 with an increase in reinforcement from 0% to 15% volume fraction. Microstructure of the composite is used to identify the distribution of reinforcement particle.*

Keywords—Al7075,RedMud,TwostepStirCasting

1. INTRODUCTION

Composites are recently attracted by many researchers because of the benefits attained from them compared to traditional materials. Particularly, MMCs having a superior performance than all other materials play a major role in the field of research.

Metal matrix composites (MMCs) provide significantly enhanced properties such as higher strength, stiffness, and weight savings compared to conventional monolithic materials[1]. MMCs combine metallic properties (ductility and toughness) with ceramic properties (high strength and high modulus) which lead to greater strength in shear and compression and higher service temperature capabilities.

Al7075 is an alloy of Aluminium used in aircrafts, automobiles and sporting goods it's having a high strength, even with a light weight and has a good resistance to corrosion. Al7075 employed in composites as a matrix yield a better performance than the matrix alone[2].

The main problem associated with the Metal Matrix Composites is their higher cost of reinforcement. To overcome this obstacle, a need arises to look for low cost reinforcements such as Red mud, Fly ash, and graphite etc. which may result in better properties of the developed composite. Further, the use of red mud as a reinforcement material will consume a waste product which otherwise can cause disposal problem and environmental hazards.

A large number of manufacturing methods are used to place reinforcement in to matrix alloy. Certain available methods are stir casting, squeeze casting, liquid metal infiltration, Powder metallurgy and spray co-deposition[3].

Stir casting technique is one of the promising route for producing large size components and high volume production[4, 5].

Literature Survey of Aluminium alloy 7075 and their composites are as follows. Kumar *et.al.*[6]investigated the specific wear rate of the unreinforced Al 7075and hybrid aluminum metal matrix composite reinforced with the hard ceramic (7 wt.% of SiC) and soft solid lubricant (3 wt.% of graphite) fabricated by using stir casting method and concluded that the specific wear rate exhibited increasing trend with change of load. Kalkanli *et.al.*[7] presented the experimental results of the studies conducted regarding hardness and flexural strength of Al7075-SiC as cast and heat treated composites. Sherafat *et.al.*[8]presented the mechanical and physical properties of the Al/Al7075 two-phase material and concluded that the tensile and compression strength increases and ductility decreases when decreasing base powder. Reddy*et.al.*[9]developed Al 7075 alloy reinforced with E-glass and fly ash particulates with different composition (varying E-glass with constant fly ash and varying fly ash with constant E-glass percentage). Tensile and hardness tests were conducted and concluded that the MMC developed has got better hardness and tensile strength properties when compared to Al 7075 alone. Su*et.al.*[10] developed the Al7075 composite reinforced with SiC and studied the relationship between true stress and true strain.Yang*et.al.*[11] prepared TiC/Al7075 composite and studied the wear rates at different load conditions. Flores-Campos*et.al.*[12] fabricated the Al7075 composites with carbon-coated silver nano particles and concluded that Vickers micro hardness (HVN) values are higher at higher Ag-CNP

contents. Doel *et.al.*[13]fabricated Al7075/SiC (5, 13 and 60μm) composites and concluded that tensile strength were improved for 5 and 13 μm SiC particles than that of base alloy.

Based on the above discussion there is no enough data available on the mechanical and physical properties of Red mud reinforced Al7075 composites.

The main aim of the present study is to fabricate of Al7075 with Red mud composites containing various volume fractions of particles and to study their physical and mechanical properties.

2. EXPERIMENTAL DETAILS

The base matrix and the reinforcing phase for the present studies selected were Al 7075and Red mud. The chemical composition of matrix and properties of matrix tabulated in Table 1 and Table 2.Sample of the hybrid composites were prepared by two step stir casting route[14], [15]. 5, 10, 15 vol. % of reinforcements were used to prepare composite material. The amounts of the matrix material and the reinforcements were determined by calculating the volume percentages. The melting was carried out in a furnace and the stir process completed with the help of fire resistant stirring motor arrangement and speed regulator is shown in Figure 1. The Red mud reinforcement was preheated before adding into Aluminium melt. The aluminum material was first heated above the liquidus temperature to melt completely. It was then slightly cooled below the liquidus temperature to maintain the slurry in the semi-solid state. The preheated reinforcements were added into the molten metal and mixed manually. Then the composite slurry was reheated to a liquid state and mechanical mixing was carried out for about 10–15 min at an average mixing speed of 150–300 rpm. The final temperature was controlled to be within 800°C±10°C. Finally, the melted material was transferred to a mild steel die with dimension of 150 x 60 x 50 mm^3. After completing solidification processes, the ASTM standard test specimen were prepared.In this paper, sample 1 contains pure Al7075, sample 2 contains 95% Al7075 + 5% Red mud, sample 3 contains 90% Al7075+ 10% Red mud, and sample 4 contains 85% Al7075 + 15% Red mud.

Table 1: Chemical Composition of Al7075 by Weight percentage.

Chemical Composition	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
Al7075	0.4	0.5	1.6	0.3	2.5	0.1	5.5	0.2	Balance

Table 2: Properties of Al 7075

Properties	Al 7075
Elastic Modulus (Gpa)	70-80
Density (g/cc)	2.81
Poisson's Ratio	0.33
Hardness (HB500)	60
Tensile Strength (T) / Compressive Strength (C) (Mpa)	220(T)

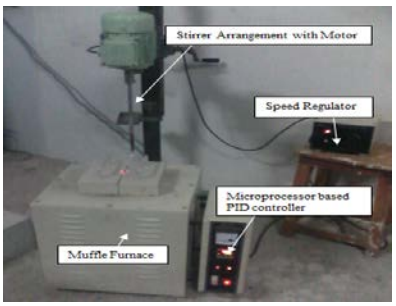

Fig. 1.Stir Casting Setup

Wilson micro Vickers hardness tester served the purpose of measurement of micro hardness. The polished and mirror finished specimens were examined under inverted microscope to obtain microstructures. The tensile properties were evaluated by universal testing machine.

3. RESULT AND DISCUSSION

A. *Microstructure and Micro Hardness*

The Vickers micro-hardness of cast Al7075 base matrix and their composites are evaluated as per the standard of ASTME384-11 using diamond indenter at an applied load of 500g with dwell period of 10s.The composite containing higher reinforcement material reveals higher hardness. The Figure 3 represent microstructure of the composites. From the microstructure, it can be observed that reinforcements were uniformly distributed in the matrix material and also clearly show the increased reinforcement content in the composite. The micro hardness values are represented in the Figure 4.

The micro hardness of the composites are higher than the base cast alloy.

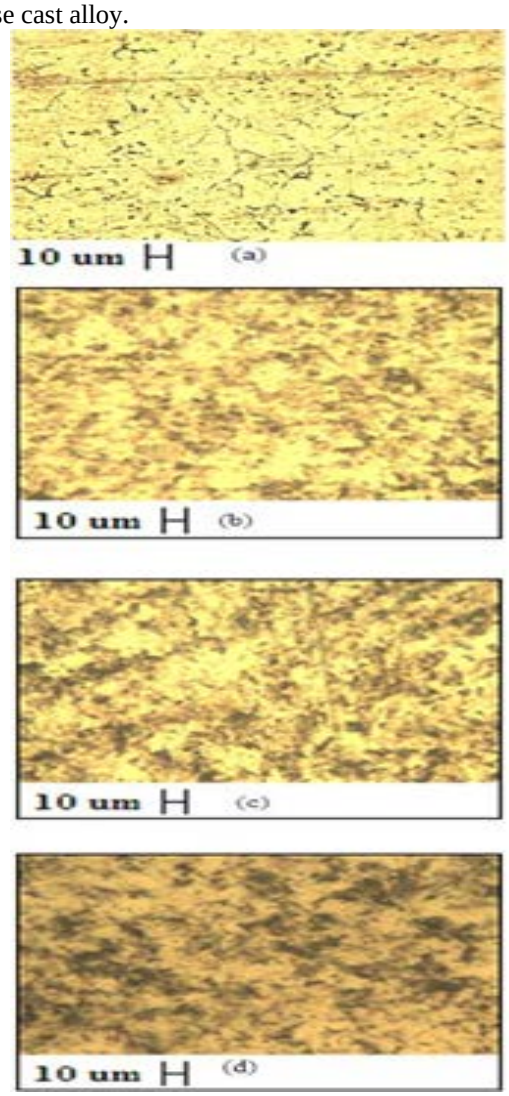

Figure3: Optical Microstructures of (a) Al 7075 (b) 95 vol % Al-7075 + 5 vol % Red Mud (c) 90 vol % Al-7075 + 10 vol % Red Mud (d) 85 vol % Al-7075 + 15 vol % Red Mud

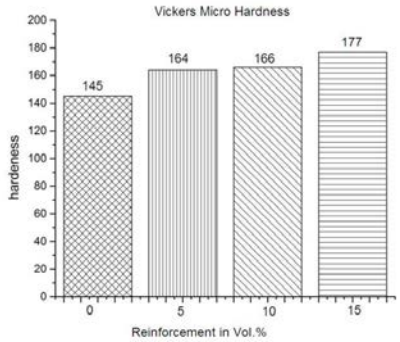

Figure 4: Vickers Micro Hardness values of Red mud reinforced Aluminium 7075 composite.

B. Tensile Strength

The tensile specimens are prepared as per the ASTM E8M-13a sub size as shown in Figure 5. Tensile test was performed with samples in the Universal tensile machine with a strain rate of 1mm/min. Figure 6 shows the tensile strength values of the Al7075 composites containing Red mud. The tensile strength increased with increasing reinforcement content up to 10 vol. %

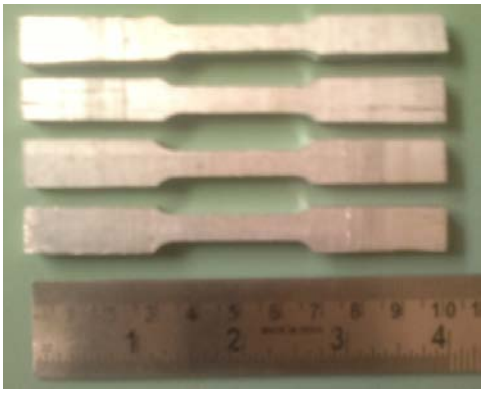

Figure 5: Tensile Test Specimen.

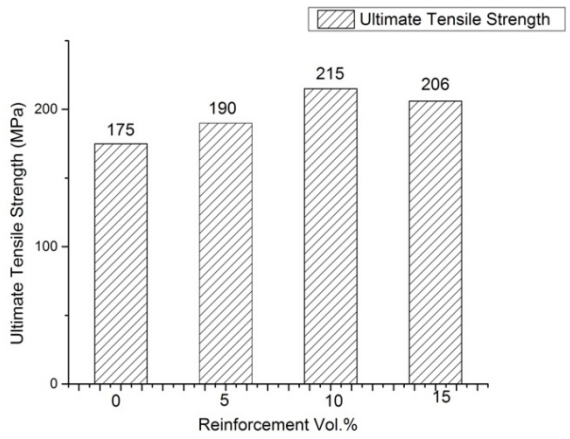

Figure 6: Tensile Strength of Red mud reinforced Aluminium 7075 composite

4. CONCLUSION

Testing results have provided the following conclusions and salient observations:

- The manufactured composite exhibited higher values of Tensile Strength, hardness than the base alloy by two step stir casting.
- Micro hardness of the composite material were increased with an increase in reinforcement from 0% to 15% volume fraction**.**
- Microstructure of the composite material revealed the uniform distribution of reinforcement in the matrix material.
- In tensile test, the composite containing 10 vol. % Red mud showed the maximum strength of 215 MPa increased by about 40 MPa.

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