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Evaluation of Red Mud Reinforced Al-2024 MMC Fabricated using Stir Casting Technique

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Abstract—*In this paper Aluminium alloy (Al-2024) metal matrix composite (MMC) is fabricated with two different grain size and three different weight percentage of red mud particles by Liquid metallurgical technique. Effects of red mud particles on the mechanical properties of the composite are studied. Result reveal that tensile strength and hardness of the composite increases with the decrease in particle size and increase in weight fraction of red mud particles. Scanning electron microscopic (SEM) observations reveal the uniform distribution of red mud particles in the MMC. XRF test confirms the presence of red mud particles in the developed MMC.*

Keywords*: Red Mud, Al-2024 MMC, Stir Casting, SEM, XRF*

1. INTRODUCTION

Metal matrix composites (MMCs) represent a new generation of engineering materials in which a strong ceramic reinforcement is incorporated into a metal matrix to improve its properties including specific strength, specific stiffness, wear resistance, excellent corrosion resistance and high elastic modulus [1,2]. They usually consist of a continuous phase called the matrix and discontinuous phase in the form of fibres, whiskers or particles called the reinforcement [3].

Aluminum matrix composites are emerging as advance engineering materials due to their strength, ductility and toughness. Aluminium alloys are still the subjects of intense studies, as their low density gives additional advantages in several applications [4]. Aluminium alloy 2024 has good machining characteristics, higher strength and fatigue resistance [5]. It is widely used in aircraft structures, especially wing and fuselage structures under tension. It is also used in high temperature applications such as in automobile engines and in other rotating and reciprocating parts such as piston, drive shafts, brake- rotors and in other structural parts which require light weight and high strength materials [6].

Among the various reinforcements used for developing MMC's red mud is emerging because of its low cost and availability in huge quantity. Red mud emerges as the major waste material during production of alumina from bauxite by the Bayer's process. It comprises oxides of iron, aluminium, titanium and silica along with some other minor constituents [7]. The addition of reinforcing phase significantly improves the tribological properties of aluminium and its alloy system [8,9].

2. EXPERIMENT PROCEDURE

The MMC was manufactured using stir casting technique. Al-2024 aluminium alloy is used as matrix material and red mud is used as the reinforcement. The aluminium alloy was fed into the muffle furnace and was melted at 800ºC. Red mud of required wt% and with grain size of 90 µ was first preheated to 800ºC for 4 hrs and then fed into the molten aluminium alloy. Stirring was done at 700 rpm constantly with a stirrer. Small amount of magnesium was added to increase the wettability. The melt with the reinforced particulates were then poured to a prepared cylindrical mould. After pouring is over the melt was allowed to cool and solidify in the mould. The same procedure was followed to prepare other samples of different wt % of red mud ranging from 5% to 15% with grain size of 90µ and 150µ respectively.

Table 1: Composition of Al-2024

Con	Cu	Mg	Si	Fe	Mn	Zn	Ti	Cr	Al
%	4.29	1.29	0.07	0.20	0.54	0.03	0.06	0.01	Rem

Table 2: Composition of Red Mud

Con	Al2O3	Fe2O3	SiO2	TiO2	Na2O	CaO	LOI
%	17-19	35-36	7-9	14-16	5-6	3-5	10-12

Testing

The fabricated specimens were subjected to tensile test and hardness test. SEM test was conducted to check the distribution of red mud particles in the prepared MMC. XRF test was performed to confirm the presence of red mud particles in the developed MMC.

3. RESULTS AND DISCUSSION

3.1 Tensile Strength

The prepared samples were machined for tensile specimen with circular cross section as per ASTM (E8-B557) standards . The tensile tests results are shown in Fig. 1. The tests revealed that the tensile strength increased almost linearly with increasing weight % of red mud particles for grain size of 90µ. However for grain size of 150µ tensile strength decreased from 5% to 10% and then again increased for 15% wt% of red mud particles. Tensile strength values for 150µ grain size was higher at 5% than 90µ grain size but then significantly dropped to lower values for 10% and 15% wt% of red mud.

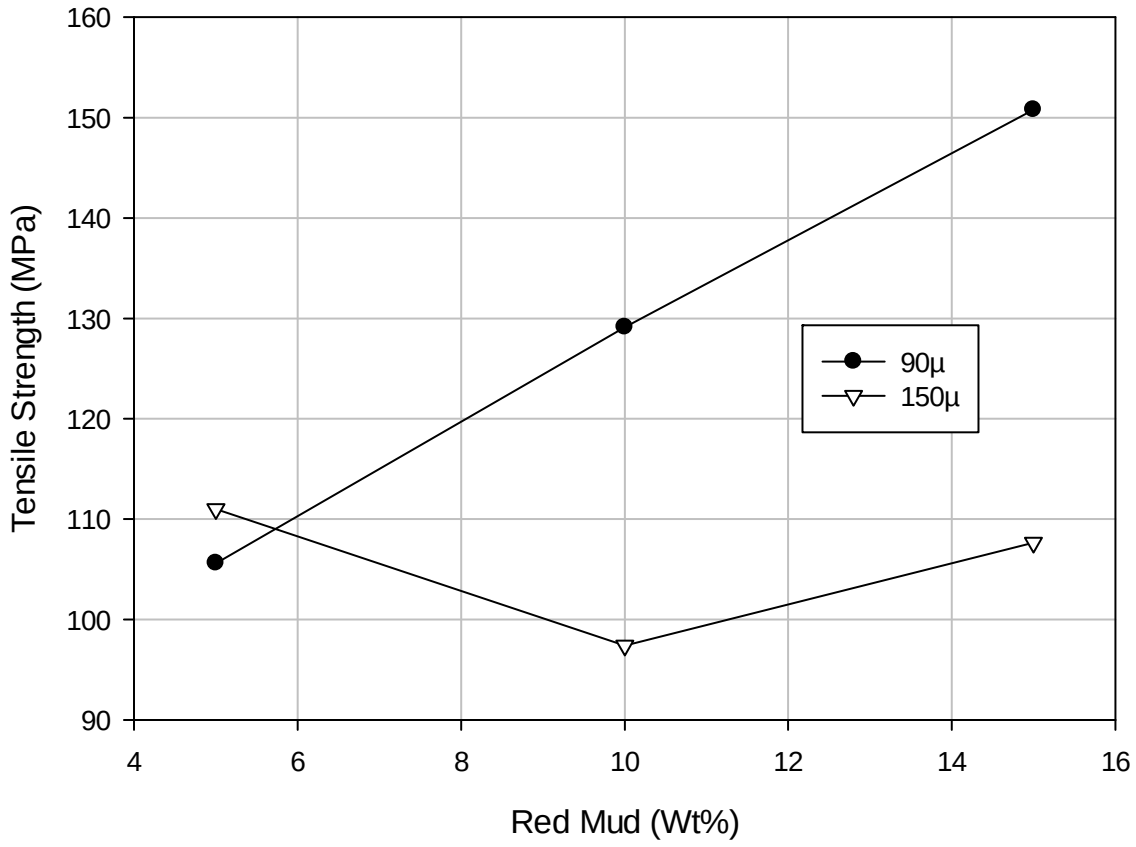

Fig. 1: Variation of Tensile Strength with wt% of red mud in Al2024/red mud MMC

3.2 Hardness

The required samples are prepared from the cast specimen for micro-hardness test (HV). The tests revealed that hardness of the composite increased with the increase in weight % of red mud for both the particle sizes but the values for 150µ particle size were lower at all levels of different wt% of red mud as compared to the 90µ particle size. The results are shown in Fig. 2.

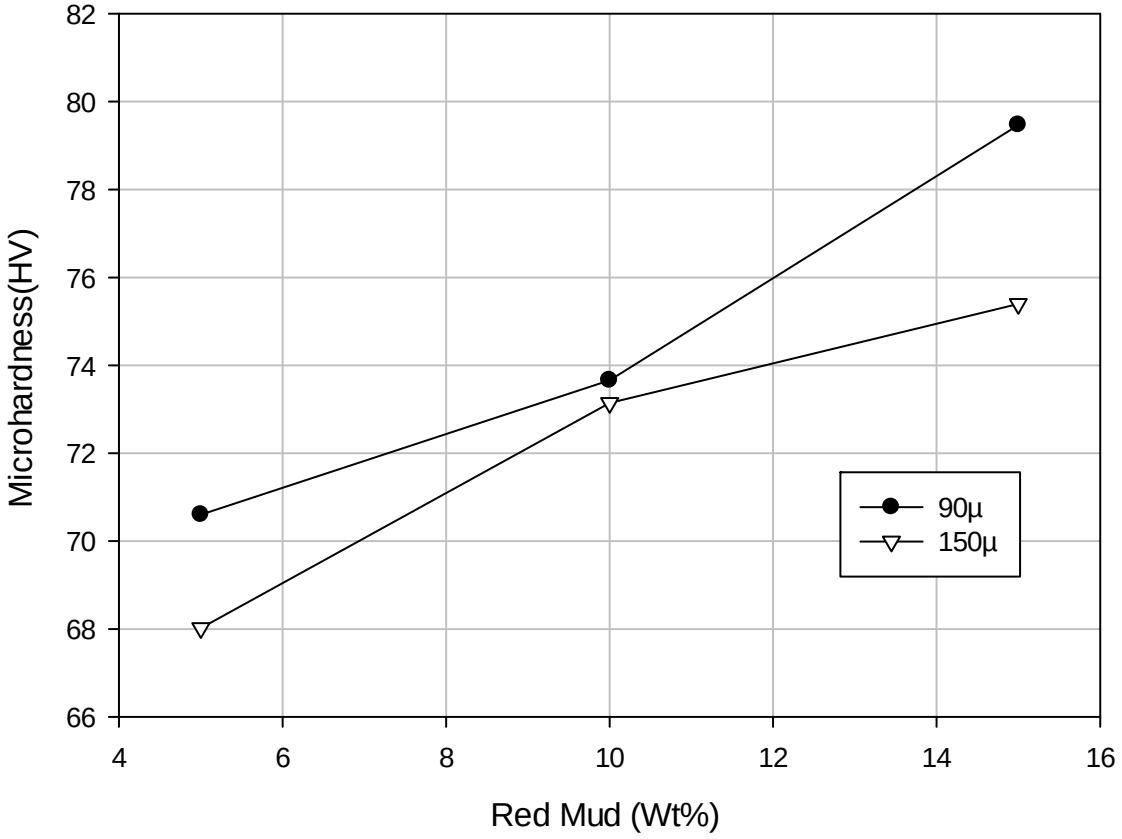

Fig. 2: Variation of micro-hardness with wt% of red mud in Al2024/red mud MMC

3.3 SEM and XRF Analysis:

The samples were prepared for SEM and XRF testing. SEM micrograph shown in Fig. 3 clearly show the uniform distribution of red mud particles in the composite and XRF test result shown in Fig. 4 confirms the presence of red mud particles in the prepared samples.

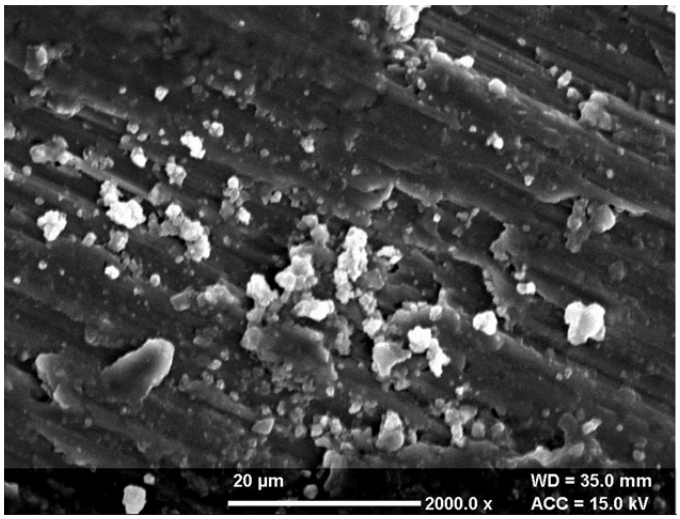

Fig. 3: SEM micrograph of Al2024/red mud composite

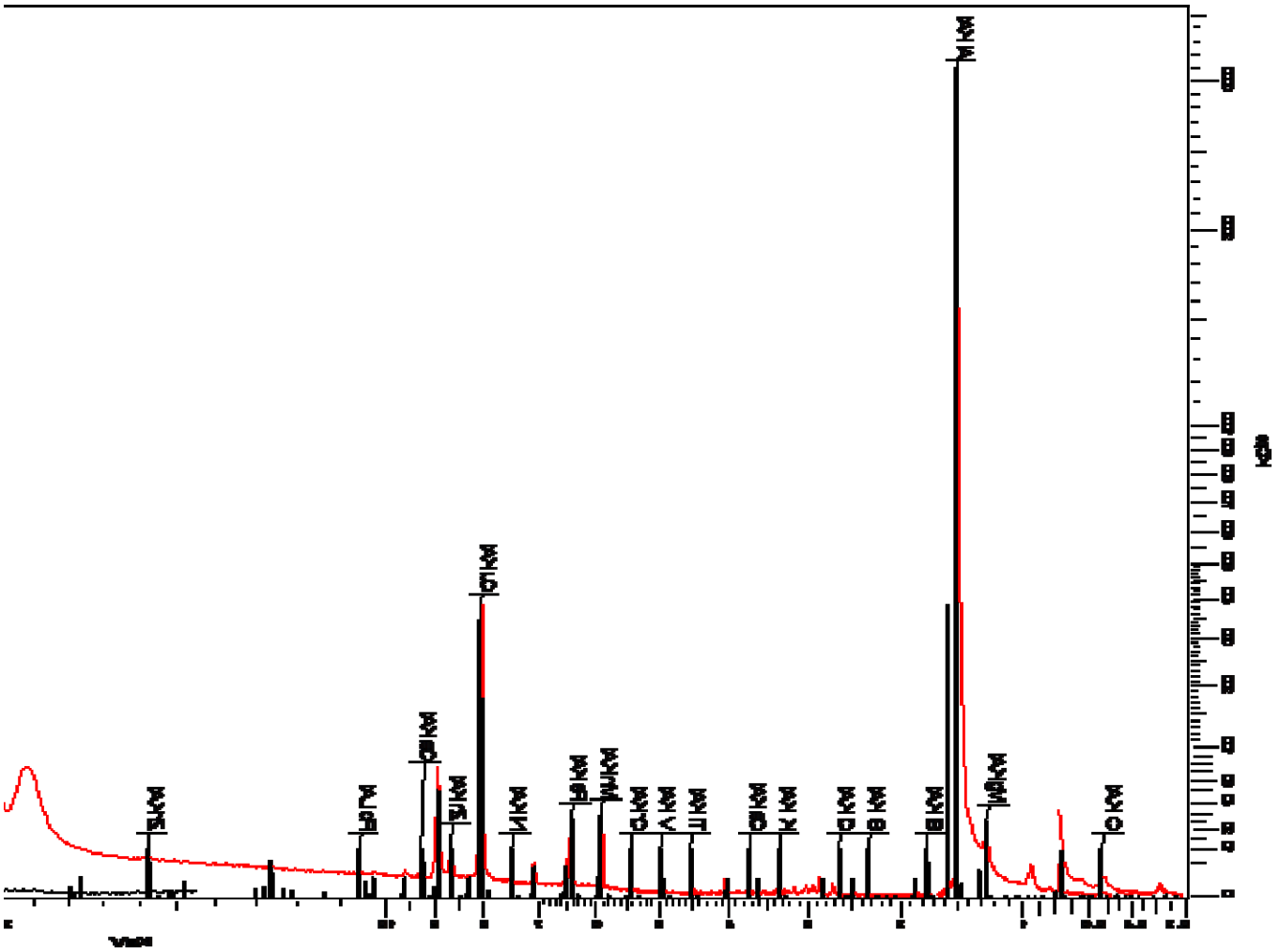

Fig. 4: XRF pattern of Al2024/red mud composite

4. CONCLUSION

In this paper Al-2024/Red mud MMC is successfully fabricated with different wt % of red mud using two different grain sizes of red mud particles. The prepared samples were subjected to mechanical testing, SEM and XRF for investigation. The following conclusions have been drawn:

1. Tensile strength and hardness increased with increasing wt% of red mud and was found to be maximum at 15% wt% of red mud and 90µ grain size.
2. SEM images showed the uniform distribution of red mud particles in the developed MMC.
3. XRF test confirms the presence of red mud particles in the developed MMC.

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