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Influence of Mechanical Properties on Al5083 Metal Matrix Composites

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Abstract
Aluminum metal matrix composites (AMMCs) have garnered significant attention across various industrial sectors owing to their remarkable properties compared to conventional engineering materials. These include low density, high strength-to-weight ratio, excellent corrosion resistance, enhanced wear resistance, and favorable high-temperature properties. These materials find extensive applications in the military, automotive, and aerospace industries. AMCs are manufactured using diverse processing techniques, tailored to their specific classifications. In this study explores the advancement of aluminum-based composites through the integration of cerium oxide (CeO_2) reinforcement via stir casting. The Composites prepared by adding reinforcement particle into matrix material from 1.5wt% to 3wt% with interval of 0.5wt%. The prepared composites characterized for mechanical behaviour like tensile and hardness. The tensile test carried out by Universal Testing Machine (UTM) and hardness test carried out by Brinell Hardness machine. From the results obtained it was observed that with the increases in weight percentage of CeO_2 reinforcement particle the UTS and hardness value of the composite material increases.
Keywords: ***Aluminium 5083, CeO_2, Mechanical Properties.***

1. INTRODUCTION

Many of the modern technologies require materials with unusual combination of properties that cannot be met by the conventional materials. This is especially in materials for aerospace, automotive and space applications. The materials available to the engineers include metal, ceramics, and plastics. Use of composite materials, which is a combination of two and more of metals, ceramics and polymers is another class of materials rapidly increasing. Composite materials are likely to provide engineers with materials having tailor-made properties that are impossible to achieve in conventional materials.

Metal matrix composites have been the object of an intense research effort for more than thirty years. Metal matrix composites exhibit significant increase in stiffness and mechanical strength compared to matrix alloys, but suffers from lower ductility and inferior fracture toughness. Metal matrix composites containing hard particulates offer superior operating performance and resistance to wear. In industrial processes, elements fabricated from MMC materials exhibits higher abrasive resistance leading to longer service life. Metal matrix composites are gaining widespread popularity in several technological fields owing to their several advantages. Several interesting applications are piston, connecting rod, microwave filters, vibrator component, contactors, impellers and space structures [1].

J Hashim et.al. have studied the vortex method is one of the better known approaches used to create and maintain a good distribution of the reinforcement material in the matrix alloy. In this method,

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after the matrix material is melted, it is stirred vigorously to form a vortex at the surface of the melt, and the reinforcement material is then introduced at the side of the vortex. The stirring is continued for a few minutes before the slurry is cast. During stir casting for the synthesis of composites stirring helps in two ways: (a) transferring particles into the liquid metal, and (b) maintaining the particles in a state of suspension [2] .
M. Amra et.al. have studied nano-sized cerium oxide (CeO_2) and silicon carbide (SiC) particles were stirred and mixed into the surface of an Al5083 alloy rolled plate using friction stir processing (FSP) to form a surface nano-composite layer. For this purpose, various volume ratios of the reinforcements either separately or in the combined form were packed into a pre-machined groove on the surface of the plate. Microstructural features, mechanical properties, and corrosion behavior of the resultant surface composites were determined. Microstructural analysis, optical microscopy and scanning electron microscopy, showed that reinforcement particles were fairly dispersed inside the stir zone and grain refinement was gained. Compared with the base alloy, all of the FSP composites showed higher hardness and tensile strength values with the maximum being obtained for the composite containing 100% SiC particles, i.e., Al5083/SiC [3].
Sourabh Gargatte et. al. have reported the dry sliding wear behaviour & Brinell’s hardness test of AA 5083 aluminium reinforced with SiC particles fabricated by stir casting technique. Different volume fraction of SiC particles (3, 5 and 7 wt %) were used for synthesis. The wear test has been conducted on pin-on-disc testing machine to examine the wear behaviour of the aluminium alloy and its composites [4].

2. MATERIALS AND METHODS

2.1 Aluminium-5083:

In marine industry, increase in usage of aluminium is through capitalizing on its prominent qualities. The two major potentials in selecting aluminium are in its lightness and corrosion resistance. Hence commonly used aluminium alloy which exhibit suitable strength plus excellent corrosion resistance is 5xxx series or Al-Mg alloy. Al-5083 alloy consists of magnesium as principle alloying element with bits of manganese and chromium in it. As a result for the reason of its high resistance to corrosion with high strength, hence it is widely used in ship building and pressure vessels etc. In the present investigation Al-5083 was preferred as the matrix material in improvement of composite.

Table 2.1 Chemical Composition of Al 5083

ELEMENTS	PERCENTAGE (%)
Si	0.4
Fe	0.4
Cu	0.1
Mn	0.4-1.0
Mg	4-4.9
Zn	0.25
Ti	0.15
Cr	0.05-0.25
Al	**Balance**

2.2 Cerium oxide:

Cerium oxide, also known as ceric oxide, ceric dioxide, ceria, cerium oxide or cerium dioxide, is an oxide of the rare earth metal cerium. It is a pale yellow white powder with the chemical formula CeO_2. It is an important commercial product and an intermediate in the purification of the element

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from the ores. The distinctive property of this material is its reversible conversion to a nonstoichiometric oxide.[3]

Figure 2.1 Al 5083 Matrix material and Cerium Oxide (CeO_2) Reinforcement material

2.3 Preparation of Composites:

A stir casting process was used to fabricate the aluminum base matrix alloy fused with cerium oxide has reinforcement particle varying from 1.5 wt.% to 3 wt.% in steps of 0.5 wt.% for the preparation of metal matrix composites. The matrix alloy was melted in a casting furnace at around 800°C shown in figure 1. At the same time, the cerium oxide particulate preheated to remove surface impurities and assist in the adsorption of gases. Then the preheated 1.5 wt. % of cerium oxide particulates was introduced evenly into the molten metal alloy. Using stirrer the cerium oxide was mixed with Al5083 with a speed of 500rpm for 15mins. Then the molten metal was poured into the die, before pouring the molten metal into the die was preheated to certain temperature. So that it equals the molten metal temperature and removes all entrapped gases. The molten metal takes more than an hour to solidify and takes the counter shape of the die. Later the die is dismantled and cast product is taken out. This process was repeated for 2, 2.5 and 3 wt. % reinforcement. The samples are prepared for testing as per ASTM standards[5-11].

Figure 2.2 - Electrical Induction Furnace and Stirrer

Fig 2.3 - Die used and Casted product

3. RESULTS AND DISCUSSION

3.1 Tensile test

Tensile test was carried out by using Universal Testing Machine for developed composites. Specimens were prepared and tested as per as per ASTM standards. The Ultimate Tensile Strength (UTS) is increased with increase in CeO_2 reinforcement up to 2.5wt% and it decreases at 3wt%. The specimen of tensile test is as shown in figure 3.1.

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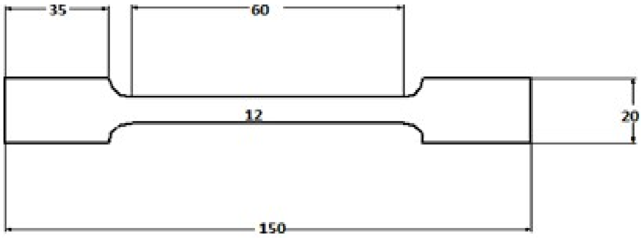
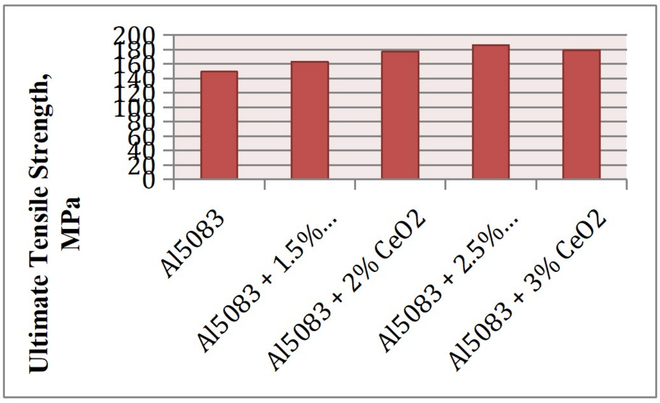


Figure 3.1 Tensile Specimen

Figure 3.2 Before Test

Figure 3.3 After Test



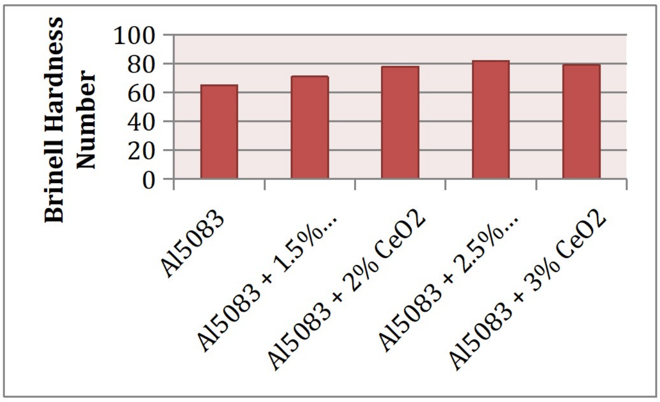
Variation of UTS with percentage of reinforcement

3.2 Hardness Test

The hardness testing was carried out for all polished composite specimens prepared from the developed metal matrix composite. The hardness of the specimen determined by Brinell hardness testing machine. The indentation time for the hardness measurement was one minute. The tests were carried out at five different locations. Each hardness result was obtained from an average of at least five repetitions on the same sample. From the results obtained it was observed that with the increases in weight percentage of CeO2 reinforcement particle the hardness value of the composite material increases. Hardness increases upto 2.5wt% thereafter gets decreases.

Figure 4.5 Before Test

Figure 4.6 After Test



Variation of Hardness with percentage of reinforcement

4. CONCLUSIONS

The above review for the stir cast of aluminium based metal matrix composite leads to the following conclusions:

- Stir casting method can be successfully used to manufacture metal matrix composite with desired properties.
- From the tensile test study it was seen that ultimate tensile strength of the composite having 2.5wt% of cerium oxide was more and hence desirable.
- The brinell hardness no. of the composite increases upto 2.5wt% of cerium oxided and further decreases.
- From the study, Reinforcing aluminium and its alloy with cerium oxide particles has shown an appreciable increase in mechanical properties.

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