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Characterization on Aluminium Alloy 7050 Metal Matrix Composite Reinforced with TiO2

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Abstract – *Metal Matrix composites based on aluminum were developed for light weight applications particularly in aerospace and automobiles sector. The present work deals with the development and characterization of Aluminum alloy 7050 matrix composite reinforced with Titanium Oxide of 6%. Stir casting process were adopted for fabricating the composite. The mechanical properties such as hardness, tensile strength, compression strength and microstructure will be studied and compared with those of base alloy.*

Key Words: Metal Matrix Composite, Aluminium alloy 7050, Titanium Dioxide, Stir Casting, Hardness, Compression Strength, Tensile Strength, Microstructure Behaviour.

1. INTRODUCTION

Metal Matrix Composite (MMC) is widely used in industry to make appropriate changes in the properties of the base metal. Metal matrix composites have a high application potential in automotive engineering in braking systems, piston rods, piston pins, pistons, frames, valve spring caps, brake discs, disc brake caliper, brake pads, card a shaft etc. They have also found application in military and civil aviation in the area of axle tubes, reinforcements, blade and gear box casing, turbine, fan, and compressor blades. In the aerospace industry MMCs have been applied in frames, reinforcements, aerials, joining elements etc. Al-based metal matrix composites (MMCs) are well-known for their high-specific strength, hardness, and attractive tribological properties.

Aluminum metal matrix composites significantly enhanced the mechanical properties compared to the unreinforced aluminum alloys. The reason for preferring the aluminum composite because of its availability, it has high toughness, strong mechanical strength, and good stress corrosion cracking resistance. AMMC's strength can be reduced at high temperatures. Aluminium metal matrix composites have potential demand in various structural applications such as aerospace, construction, automobile due to their remarkable characteristics in comparison with conventional alloys. Al 7050 is widely used and suitable alloy among the Al-7xxx series for transportation applications. The physical, mechanical, tribological and microstructure characteristics of Al 7050 metal matrix can still be improved with the addition of suitable reinforcing materials. Aluminum used in mainly in automotive and aerospace industries so they need less weight more strength.

Various reinforcements are used in aluminum composite materials such as silicon carbide, aluminum oxide, boron carbide, graphene, graphite etc., Titanium oxide was found to be most effective in enhancing the strength properties of Aluminum when incorporated via ingot metallurgy process. Titanium Oxide has the excellent mechanical characteristics cause a great potential in strengthening elements in polymer, ceramic and metal-matrix composites for functional and structural applications. To alter the mechanical properties of aluminum such as tensile, hardness etc. by adding reinforcement such that due to that added material we get the desired properties.

2. EXPERIMENTAL WORK

2.1 Materials

Al 7050 is selected as the base material because of its availability and mechanical properties. The composition and the properties are explained in the following table.

Table -1: Chemical Composition of Al 7050

Element	Content %
Aluminium, Al	89
Copper, Cu	2.3
Magnesium, Mg	2.3
Zinc, Zn	6.2
Zirconium, Zr	0.12

Table -2: Properties of Al 7050

Properties	Metric
Density	2.6-2.8 g/cm^3
Melting point	494℃
Tensile strength	515 MPa
Yield strength	455 MPa
Fatigue strength	240 MPa
Elastic modulus	70-80 GPa
Elongation	11%
Thermal conductivity	180W/mK

2.2 Reinforcement

Titanium Dioxide, also known as titanium oxide or Titania, it is the naturally occurring oxide of titanium, chemical formula TiO_2. When used as a pigment, it is called titanium white, Pigment White or CI 77891. Titanium dioxide has the grain size of 25µm. the various applications of titanium oxide are it exhibits good photo catalytic properties, hence used in antiseptic and antibacterial compositions. It is used for manufacturing of printing ink, self cleaning ceramics and glass, coating etc. Making of cosmetic products such as sunscreen cream, morning and night cream, skin milks, etc. used in the paper industry for improving the capacity of paper. The properties are explained in the following table.

Table 3: Properties of the Titanium Oxide

Properties	Metric
Density	4.23 g/cm^3
Melting Point	1,843ºC
Tensile strength	367.5 MPa
Elastic modulus	230 GPa
Thermal conductivity	11.8 W/mK

2.3 Working Procedure

The stir casting method was used for MMC of Al 7050 alloy and the reinforcement particle. The materials are preheated to a temperature near to that of the main process temperature. The purpose of preheating is to remove the water vapor and other contaminants present in the metal powders.

The furnace temperature is maintained around 700-750℃and the pre heated Al 7050 around 600-800℃. At this temperature the Al 7050 alloy is placed inside the crucible and starts melting at the temperature up to 800℃where the Al 7050 is in liquid molten state.

The Al 7050 3 hours for melting while the titanium oxide is weighed according to the Al 7050 billet weights. The temperature of crucible is maintained around 950℃, the speed is maintained around 380-400 rpm. The De-gassing tablet is added to minimize the oxide formation during the process. The pre heated reinforcement (6% wt TiO_2) up to 450℃ is added by pouring slowly into the crucible and stirred for 15-20 mins. The stirred is removed and the temperature is increased. The pre heated mold is kept ready for pouring the molten composition, the molten composition is stirred for 5-10 mins then poured into the mold and allowed to solidify. Then the mold is disassembled to obtain the Aluminium Metal Matrix Composite.

3. RESULTS AND DISCUSSIONS

3.1 Tensile Strength: Tensile strength, maximum load that a material can support without fracture when being stretched, divided by the original cross-sectional area of the material. When stresses less than the tensile strength are removed, a material returns either completely or partially to its original shape and size. The tensile specimen of AMMC's is machined as per ASTM E8-16a standards and tested through Universal testing Machine (UTM TUE-C-600).

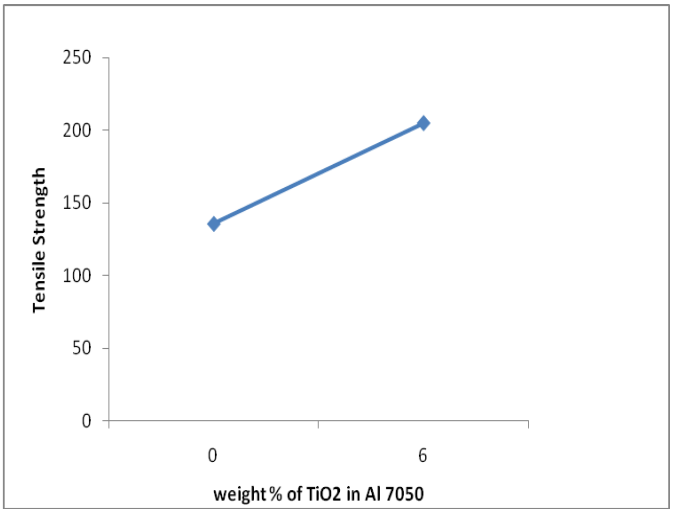

Fig-1 Ultimate tensile strength of Al 7050 reinforced with 0 and 6 % TiO2

The tensile strength of Al 7050 and composite with 0 and 6 wt% TiO_2 are illustrated in Fig-1. From the fig it is seen that the Al 7050-6% TiO_2 composite has increase in the tensile strength as 204.90 N/mm^2. The composite material has the higher tensile strength than Al alloy 7050.

3.2 Compression strength: Compression tests are also used to determine the modulus of elasticity, proportional limit, compressive yield point, compressive yield strength,

and compressive strength. These properties are important to determine if the material is suited for specific applications.

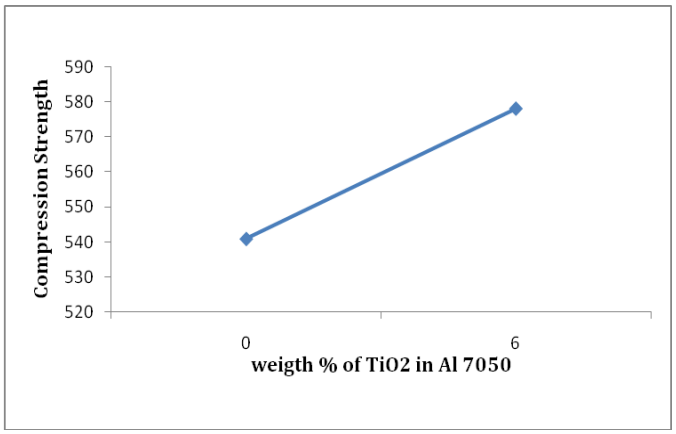

Fig-2 Compression strength of Al 7050 reinforced with 0 and 6 % TiO2

The Compression strength of Al 7050 and composite with 0 and 6 wt% TiO_2 are illustrated in Fig-2. The test result showed that the material can with stand the higher load and has 578.08 N/mm^2 value of compression strength than the base Al alloy.

3.3 Hardness: Hardness is the ability of a material to resist deformation. The specimen is prepared as per ASTM E10 standards, HBW 250 Brinell was used for testing of specimens. A load of 250 Kgf was applied with the steel ball indenter of 5mm diameter. The test was carried out at different locations to know the effect of indenter on the harder particles. Hardness was determined by measuring the indentations diameter produced.

The Fig-3 shows the Hardness of Al 7050 and composite with 0 and 6 wt% of TiO_2 . The hardness value increased compared to the base Al alloy, three indentations is done the material and higher value i.e.122.6 is considered as the hardness value of the composite.

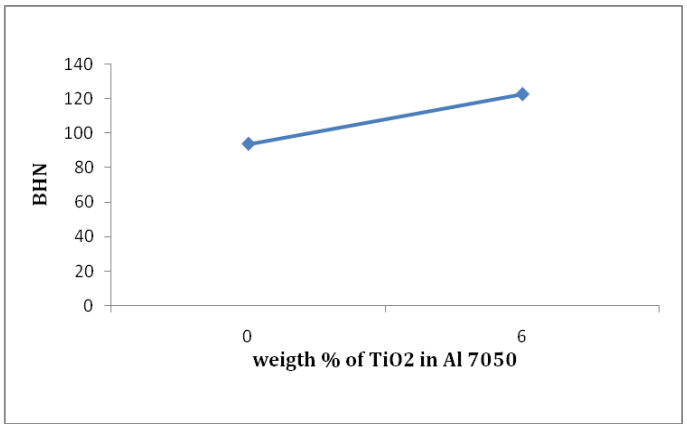

Fig-3 Hardness of Al 7050 reinforced with 0 and 6 % TiO2

3.4 Microstructure: Microstructure test are carried out to investigate of distribution of the titanium oxide in the development of AMMC's. Samples having different weight percentage of reinforcements are examined. The small pieces of cut specimens as per standard metallograph were taken and grinding through grind wheels and to get fine surface finish. A series of emery papers with grit sizes varying from 400m to 1500m were used.

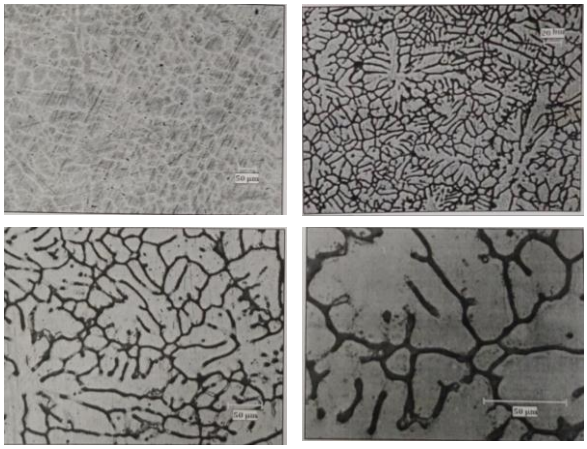

Fig Microstructure behavior of Al alloy 7050

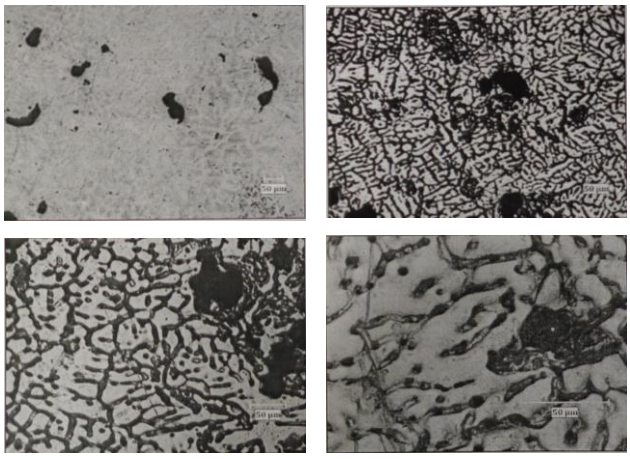

Fig microstructure behavior of Al alloy 7050 With 6% of TiO2

The microstructure images for 0 and 6 wt% of compositions composite material are taken with 100X and 500 X magnifications. It is clearly known from the above images that there is an improvement in its structure and the reinforcement causes close bonding and uniform distribution of TiO_2 particles can also be seen in this micro structural view.

4. CONCLUSIONS

The mechanical properties of the AMMC's reveals that there is increase in properties like hardness and tensile strength and in compression strength. Micro structure graph reveals uniform distribution of TiO_2 particles.

It is concluded that composite Al 7050 and 6% wt of TiO_2 indicates better Tensile strength and Hardness compared to 0% wt.

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