# Evaluation of Mechanical Properties of Aluminum Alloy 7050 Metal Matrix Composite Reinforced with Titanium Oxide 

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#### Abstract

: Metal Matrix composites based on aluminum were developed for light weight applications particularly in aerospace and automobiles sector. In this investigation Al 7050 an $\mathrm{Al}-\mathrm{Zn}-\mathrm{Mg}-\mathrm{Cu}-\mathrm{Zr}$ alloy having good mechanical properties is consider as base material with reinforcement of titanium oxide at various percentage level as $\mathbf{2 \%}$ and $4 \%$. The present work deals with the development and evaluate the mechanical properties such as hardness, tensile strength, compression strength and microstructure and compared Stir casting process were adopted for fabricating the composite.


 Keywords - Metal Matrix Composite, Aluminium alloy 7050, Titanium Dioxide, Stir Casting, Hardness, Compression Strength, Tensile Strength,Microstructure
Behaviour.

## I. 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.

## II. EXPERIMENTAL WORK

## A. Materials

Al7050 is selected as the base material because of its availability and mechanical properties. The composition and the properties are explained in the following table.
I. Table-I : 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 -II : PROPERTIES OF AL 7050

| PROPERTIES | METRIC |
| :--- | :--- |
| Density | $2.6-2.8 \mathrm{~g} / \mathrm{cm}^{3}$ |
| Melting point | $494^{\circ} \mathrm{C}$ |
| Tensile strength | 515 MPa |
| Yield strength | 455 MPa |
| Fatigue strength | $70-80 \mathrm{GPa}$ |
| Elastic modulus | $11 \%$ |
| Elongation | $180 \mathrm{~W} / \mathrm{mK}$ |
| Thermal conductivity |  |

## B. Reinforcement

Titanium Dioxide, also known as titanium oxide or Titania, it is the naturally occurring oxide of titanium, chemical formula $\mathrm{TiO}_{2}$. When used as a pigment, it is called titanium white, Pigment White or CI 77891. Titanium dioxide has the grain size of $25 \mu \mathrm{~m}$. 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 -III : PROPERTIES OF THE TITANIUM OXIDE

| Properties | Metric |
| :--- | :--- |
| Density | $4.23 \mathrm{~g} / \mathrm{cm}^{3}$ |
| Melting Point | $1,843^{\circ} \mathrm{C}$ |
| Tensile strength | 367.5 MPa |
| Elastic modulus | 230 GPa |
| Thermal <br> conductivity | $11.8 \mathrm{~W} / \mathrm{mK}$ |

## C. 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$750^{\circ} \mathrm{C}$ and the pre heated Al 7050 around $600-800^{\circ} \mathrm{C}$. At this temperature the Al 7050 alloy is placed inside the crucible and starts melting at the temperature up to $800^{\circ} \mathrm{C}$ where the Al 7050 is in liquid molten state.

The Al 70503 hours for melting while the titanium oxide is weighed according to the Al 7050 billet weights. The temperature of crucible is maintained around $950^{\circ} \mathrm{C}$, the speed is maintained around $380-400 \mathrm{rpm}$. The De-gassing tablet is added to minimize the oxide formation during the process. The pre heated reinforcement ( $2 \%$ wt and $4 \% \mathrm{TiO}_{2}$ ) up to $450^{\circ} \mathrm{C}$ 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.

## III. RESULTS AND DISCUSSIONS

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 $6 \% \mathrm{TiO} 2$
The tensile strength of Al 7050 and composite with 2 and $4 \mathrm{wt} \% \mathrm{TiO}_{2}$ are illustrated in Fig-1. From the fig it is seen that the $\mathrm{Al} 7050-4 \% \mathrm{TiO}_{2}$ composite has increase in the tensile strength as $181.323 \mathrm{~N} / \mathrm{mm}^{2}$. The composite material has the higher tensile strength than Al alloy 7050.
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 2 and $4 \% \mathrm{TiO} 2$
The Compression strength of Al 7050 and composite with 2 and $4 \mathrm{wt} \% \mathrm{TiO}_{2}$ are illustrated in Fig-2. The test result showed that the material can with stand the higher load and has $559.055 \mathrm{~N} / \mathrm{mm}^{2}$ value of compression strength than the base Al alloy.
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 5 mm 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 2 and $4 \mathrm{wt} \%$ of $\mathrm{TiO}_{2}$. The hardness value increased compared to the base Al alloy, three indentations is done the material and higher value i.e. 111.5 is considered as the hardness value of the composite.


Fig-3 Hardness of A1 7050 reinforced with 2 and $4 \% \mathrm{TiO} 2$

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 400 m to 1500 m were used.


Fig 4 Microstructure behavior of Al alloy 7050


Fig-4 Microstructure behavior of Al alloy 7050 with $2 \%$ of TiO 2


Fig 5 Microstructure behavior of Al alloy 7050 with of $4 \%$ of TiO 2
The microstructure images for 0 and $6 \mathrm{wt} \%$ of compositions composite material are taken with 100 X 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 $\mathrm{TiO}_{2}$ particles can also be seen in this micro structural view.

## IV. 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 $\mathrm{TiO}_{2}$ particles.

1) It is concluded that composite Al 7050 and $2 \%$ and $4 \%$ wt of $\mathrm{TiO}_{2}$ shows increase in mechanical properties, when compared to base material properties $4 \%$ wt of $\mathrm{TiO}_{2}$ indicates better Tensile strength, Compression strength and Hardness compared to base material and $2 \%$ wt of $\mathrm{TiO}_{2}$.
2) Microphotographs shows the distribution of reinforcements in the respective matrix are uniformly dispersed in the dendritic region in all the cases of Al7050 reinforced with 2 and $4 \% \mathrm{TiO}_{2}$ when compared to base material.

## Conflict of Interest

The authors declare no conflict of interest.

## AUTHOR CONTRIBUTIONS

Kavya B conducted the research, analyzed the data, wrote the paper and all authors had approved the final version.

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