

MECHANICAL CHARACTERIZATION OF STIR CASTED AL 6063/AL₂O₃ (ALUMINA) REINFORCED METAL MATRIX COMPOSITES

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Abstract- The present study focused on the mechanical properties of stir casted Al 6063/Al₂O₃ (Alumina) reinforced metal matrix composites. Aluminum-alumina composites are used in various industries including fabrication, aerospace, automobile sectors etc. The properties like corrosion resistance, low density, and high modulus of elasticity, higher thermal and electrical conductivity make them a best choice for its applications in various industries. The present work focus on mechanical properties of the metal matrix composite including, tensile behavior, hardness and surface characteristics of Al 6063/Al₂O₃ (Alumina) reinforced metal matrix composites by varying the percentage of the reinforced element alumina in the base matrix alloy Al 6063. The samples prepared by stir casting process by varying the percentage of alumina in the base matrix alloy Al 6063 were tested for finding the ultimate tensile strength followed by hardness and surface characteristics. The thickness of the sample were taken 6mm. The mechanical behavior was analyzed by varying the percentage of the alumina for finding the above mentioned mechanical properties for safe design and usage of the metal matrix composite.

Keywords: Aluminum, aluminum oxide, composite materials, stir casting process, tensile test, hardness test.

1. INTRODUCTION

Stir casting is a liquid state method for the fabrication of composite materials, in which a dispersed phase is mixed with a molten matrix metal by means of mechanical stirring. Stir Casting is the simplest and the most cost-effective method of liquid state fabrication. MMC materials have a combination of different, superior properties to an unreinforced matrix which are; increased strength, higher elastic modulus, higher service temperature, improved wear resistance, high electrical and thermal conductivity, low coefficient of thermal expansion and high vacuum environmental resistance.[1] These properties can be attained with the proper choice of matrix and reinforcement. Composite materials consist of matrix and reinforcement. Its main purpose is to transfer and distribute the load to the reinforcement or fibers. This transfer of load depends on the bonding which depends on the type of matrix and reinforcement and the fabrication technique.[4]. The matrix can be selected on the basis of oxidation and corrosion resistance or other properties. Aluminum based metal matrix composites have been one of the key research areas in materials processing field in the last few decades. Most of the research work has been dealing with aluminum matrix with Al₂O₃ & SiC reinforcement requiring the light weight in combination of high strength and high stiffness.[3] This is because aluminum is lighter weight which is first requirement in most of the industries. In addition, impressive strength improvement and the thermal expansion coefficient of Al matrix composites can be adjusted by using Alumina in varying proportion. Al 6063 plate is casted with varying mass of Al₂O₃ (4%, 6%, 8%).

1.1 Base Matrix Alloy

In the present study Al6063 is selected as the base matrix alloy shown in fig 1.1.

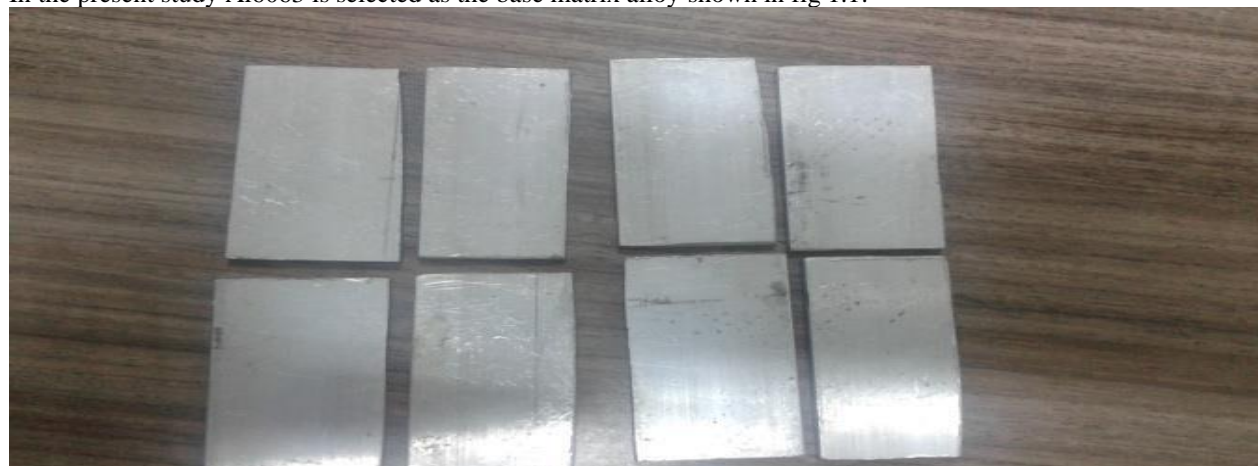


Fig. 1.1 Few Pieces of Al 6063 Alloy

1.2 Chemical Composition of Al 6063

Element	Composition
Si	0.6
Fe	0.35
Cu	0.1
Mn	0.1
Mg	0.9
Ti	0.1
Cr	0.1
Al	Balance

1.3 Mechanical Properties of AL 6063

S. No.	Mechanical Properties	Value
1	Minimum Proof Stress (0.2) %	50
2	Minimum Tensile Strength(MPA)	100
3	Shear Strength(MPA)	70
4	Hardness Vickers(HV)	25

1.4 Applications of Al 6063

Aluminium alloy 6063 is typically used in: Aircraft application, Architectural applications, Extrusions, Window frames, Doors, Shop, fittings, Irrigation tubing.

2. EXPERIMENTAL SETUP

The experimental setup consist of two furnaces for melting the base metal and the reinforcement(Alumina).Muffle furnace 1 shown below fig 2.1 for melting Al6063.And another furnace for melting alumina in fig 2.2.



Fig. 2.1 Muffle Furnace 1 with Stirrer Setup

For melting the reinforcement metal here it is alumina the furnace 2 shown in fir 2.2 is used.



Fig. 2.2 Furnace 2 for Melting Alumina

2.1 Preparation of Metal Matrix Composition

The aluminium matrix was reinforced with Al_2O_3 of 46 microns in varying percentage of 3%, 6% and 9%. The composite were cast using stir casting process as it ensures uniform distribution of the reinforcement and secondary processing like rolling is possible. Stir casting process is a special type of casting in which stirring action is carried out in the furnace itself. The various steps involved in the preparation of stir casted metal matrix composites are as follows.

- Aluminium alloy is melted at $800^{\circ}C$ in muffle furnace for two hours
- Alumina is melted at $100^{\circ}C$ in another muffle furnace for same time period
- Melted Aluminium & Alumina are mixed in the graphite crucible and 5gm of coverall, nucleant & degasser are added in the melt.
- After adding all these, the crucible is kept inside the furnace.
- At the same time, dies are preheated at $300^{\circ}C$ in another muffle furnace for 2 hours.
- At the same time, dies are preheated at $300^{\circ}C$ in another muffle furnace for 2 hours
- Finally the molten metal poured into the preheated die and then the metal is allowed to solidify.



Fig. 3.1 Stir Casted Metal matrix composite

4. TESTING

Tensile testing and microhardness testing were done on the prepared samples.

4.1 Tensile Testing



Fig. 4.1 UTM

For the safe design and usage of these composite plates, it is essential that their ultimate strength and mechanical properties need to be determined. Hence various tests are conducted using the fabricated plates. The important properties which come into play when a component is subjected to tensile loads are strength, Elasticity & Ductility. The graph below explains detail about the above parameters. From the cast MMC the standard tensile specimen were prepared by machining as per dimensions of ASTM

To obtain mechanical properties, specimens with overall length 100mm, thickness of 6mm and a gauge length of 25mm were tested in Universal Testing machine shown in fig 4.1.

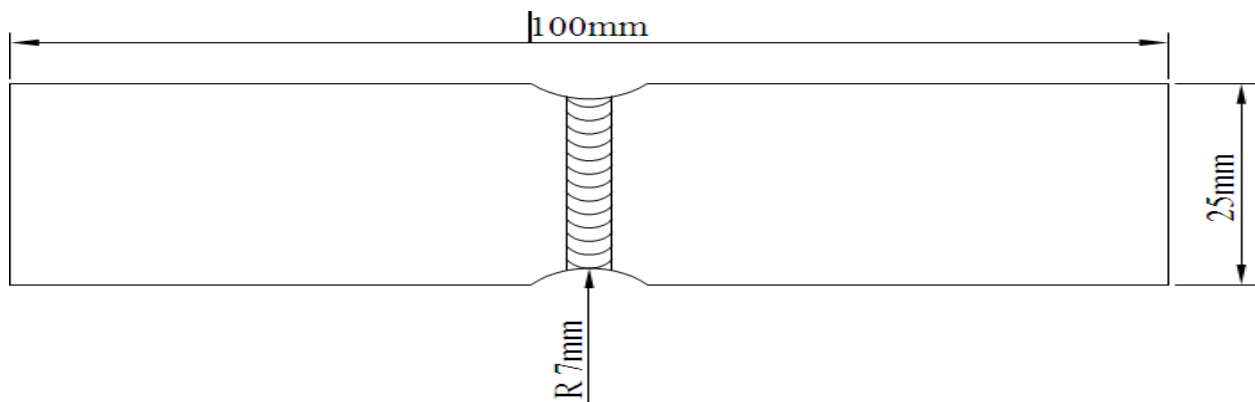


Fig. 4.2 A Standard Tensile Testing Specimen.



Fig. 4.3 Prepared Specimens with Varying Alumina Percentage

The ultimate tensile strength of a composite is affected not only by the particle and matrix fraction but also by the particle and matrix fraction but also the micro geometry of the composite components.

4.2 Micro Hardness Testing

Hardness is often a function of the particle size, porosity, and binder material. Hardness is very important to the success of machining operations. The hardness of the samples was measured using UHL Vickers micro hardness measuring machine by applying a load of 0.5Kg and this load was applied for 20 seconds. In order to eliminate the possibility of error a minimum of five hardness readings were taken for each sample.

5. RESULTS

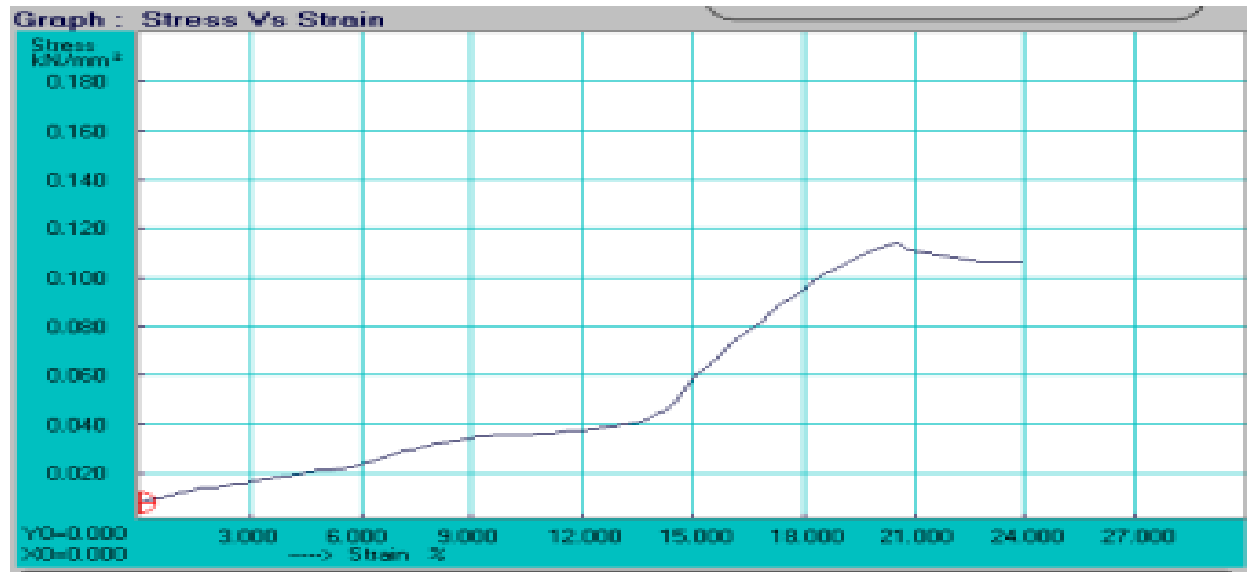


Fig. 5.1 Tensile Testing for Specimen 1 (Al6063+4%Al₂O₃)

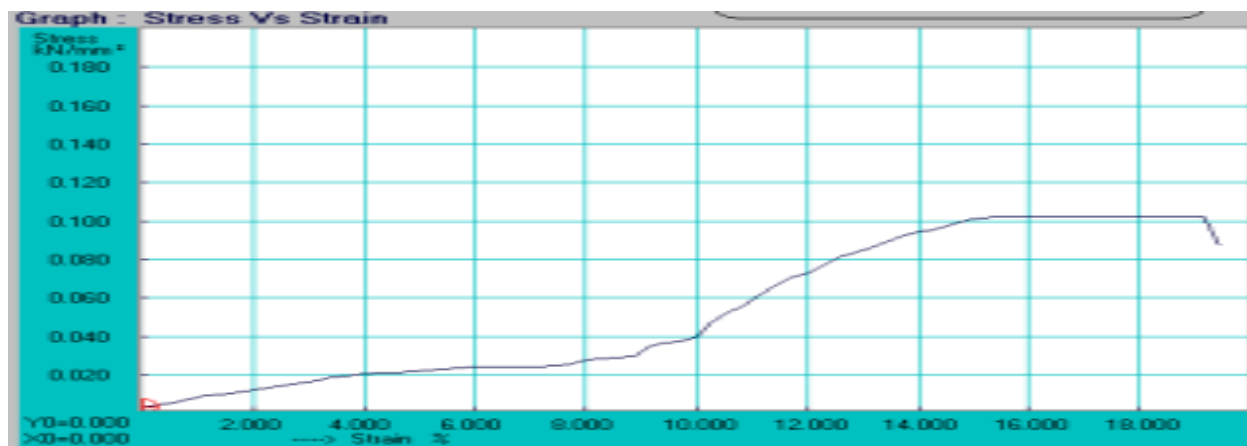


Fig. 5.2 Tensile Testing for Specimen 2 (Al6063+6%Al₂O₃)

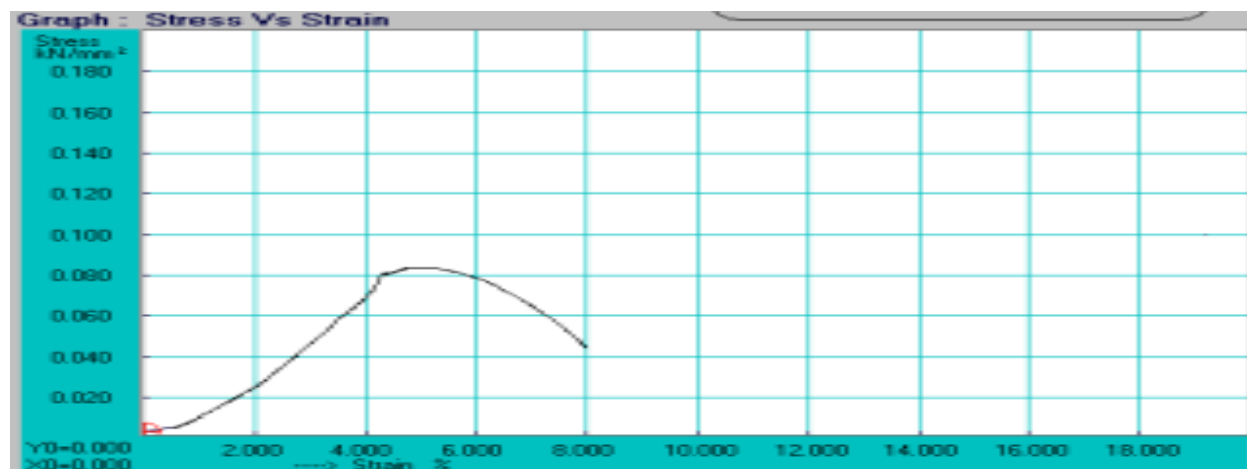


Fig. 5.3 Tensile Testing for Specimen 3 (Al6063+8%Al₂O₃)

Table-5.1 Micro Hardness Testing Result

Sample	H.V @ 0.5 Kg Load				
Al6063+3% Al ₂ O ₃	44.8	43.6	41.7	43.8	38.9
Al6063+6% Al ₂ O ₃	54.6	55.7	56.3	59.8	57.5
Al6063+9% Al ₂ O ₃	50.6	42.8	59.9	45.1	54.9

CONCLUSION

In the research work, a newly formulated composites (Al- Al₂O₃) is prepared by the stir casting process. In this stir casting method of casting Al 6063 plate is casted with varying mass of Al₂O₃ (4%, 6%, 8%).

- The results confirmed that stir casted Al alloy 6063 with Al₂O₃ reinforced composite is clearly superior to base alloy Al6063 in the comparison of tensile strength as well as hardness.
- Tensile strength of Al composite were improved by the addition of the Al₂O₃ particles. The tensile strength and porosity of 6% Vol. Al₂O₃ /Al composite decreased with increasing reinforcement
- The Percentage elongation of the composite decreased with increase in Al₂O₃ content, which confirms that alumina addition increases brittleness
- Increasing of hardness with increasing weight percentage of Al₂O₃ particles is mainly due to Grain refinement.

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