Mechanical Characterization Of Hybrid Metal Matrix Composite Reinforced With Tio_2 And Fe_2O_3 Using Stir Casting Technique

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Abstract- *The main objective of this work is to develop hybrid Metal matrix composite introducing Tio_2 and Fe_2 o_3 as reinforcement in Al-6061 alloy for producing competent industrial material with better physical and mechanical properties. Metal matrix composites are widely used due to its better mechanical and metallurgical properties. Stir casting method is opted for producing MMC, due its ease of processing and uniform distribution of reinforcement in the base metal. Present work deals with the study of Mechanical behavior of Tio_2 and Fe_2 o_3 as reinforced in Al-6061Metal Matrix Composite. Three different samples were taken with reinforcements weight percentage of 1%, 2% and 4%. All the three composites are composed by using stir casting equipment. They are compared with pure Al 6061 alloy.It is found that there is a good improvement in ultimate tensile strength, hardness and compressive strength upto reinforcement fraction of Fe2o3 and Tio2 4% in a aluminum metal matrix composite.*

Keywords- Aluminium-6061, Fe_2O_3, TiO_2, Stir casting Process, Physical and Mechanical properties.

I. INTRODUCTION

Now a day's composite materials place vital role in engineering application. While producing a new product .Composite materials are combination of two are more different materials that remains separate physical and mechanical properties and combined together form a single property. In composite material large amount of material is called Matrix's and small amount is considered as Reinforcement.

MMC's widely used in engineering application where the operating temperature lies in between 250 oC to 750 oC matrix materials relatively soft and flexible such materials are aluminium ,titanium ,copper ,magnesium and supper alloys or nickel based alloys the reinforcement must have high strength and stiffness than that materials are silicon carbide ,borin, molybdenum and alumina . Some of the examples of Aluminium metal matrix composites are Al-Sic and Al-Al2O3 among the various MMCs ,aluminium based alloy are widely used because of their superior properties. The reinforcement must have high strength and stiffness than that materials are Tic, boron carbide ,Al2O3,titanium diboride ,molybdenum disulfide ,Sic,graphite ,mica particles are widely used in AMMCs Which improves mechanical properties and tribological properties.

II. LITERATURE REVIEW

Bhanu Prakesh et al.[1] has reinforced Al-GNPs Composites By Stir Casting" .He conclude like this porosity, hardness, compressive strength and toughness increased with increasing reinforcement. the produced MMCs, Graphene with 3% yields better performance in tensile strength, hardness value and impact strength. V.Mohanavel et al.[2] the author were fabricated AA6351 aluminium alloy is matrix material and two different reinforcement Al2O3 and graphite with an average size of 60 to 70 microns. By the addition of reinforcement And he observed some of the factors and their improvement the properties of the composites increase with linearly. Himanshu Kala et al.[3] the author were introduced these reinforcement such as alumina, silicon carbide, graphite, fly ash. And the Self-lubricating property of graphite improved the machinability of aluminum. Suresha et al.[4] has fabricated composite with SiC and Graphite particles having different weight fraction. And they found that the average friction coefficient of the composites is low compared to pure alloy. Niranjan K N et al.[5] has fabricated composite with 6% of SiC and varying steps of graphite by 3%, 6%, and 9%. And they found that their macro hardness decreases with the increase in the percentage of Graphite, tensile strength and compression strength increases with the increase in graphite powder with the influence of SiC particulates. Nagara et al.[6] has fabricated composite with Al2O3/Graphite with different fraction. And he reveled the results The better hardness value was achieved forAl6061 alloy+6% of Al2O3 when compared with the Gr reinforced composites. The yield

stress was significantly increased while increasing the reinforcement percentage. The maximum yield stress was attained at Al6061 alloy+6% of Al2O3+6%Graphite. Rajmohan et al.[7] studied properties of composites fabricated with TiO2 particles of size 25 microns and graphite particles of size 45 microns with different volume proportion. And they found that the result of composite increasing while increasing TiO2 content with constant graphite proportion.

III. EXPERIMENTAL

A. Matrix Material

***Aluminium-6061*:** In this work AA6061 with therotical density of 2.7 gr/c.c is used as a matrix material .It's one of the best alloy from aluminium series . Because of it's high strength and good corrosion resistance .

Table: 1 The chemical composition of Aluminium 6061:

Alloy	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
6061	0.65	0.7	025	0.15	0.9	0.07	0.25	0.15	Reminder

B. **Reinforcement Material:** Here we have used two different types of reinforcements are Fe2O3 & TiO2.Ferric Oxide have high strength and density of this material is 5.24 gr/c.c . TiO2 has high melting point and strength material and the density is4.23 gr/c.c .

C. **Experimental Procedure:** A bottom pouring type stir casting machine is used to produce the AMMCs material .We got the material in cylindrical blocks and those were break into fine shape (Desired shape) .Initially the base metal AA6061 was poured into the 2.2 Kg capacity of furnace and the temperature was maintained around 800 oC .The solid state matrix material at 750oC temperature becomes liquid state matrix material. Then 10 grams of dry hexachloroethane tablets is added to degas the total melt. Before poured the reinforcement in molten state metal AA6061 it has preheated in muffle furnace at 750 oC for 1 hours and the stirring was done by using mechanical stirrer , speed and time of the stirrer were 300 rpm ,3 to 5 min and it is dipped upto 2/3 rd height of molten metal. During this stirring operation both matrix material and reinforcement material were uniformly mixed. The reinforcement was heated at 350 oC for 45 min. Finally the molten aluminuim hybrid metal matrix composites were transferred into permanent mould.

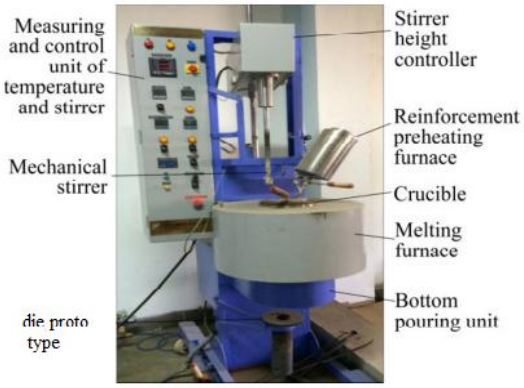
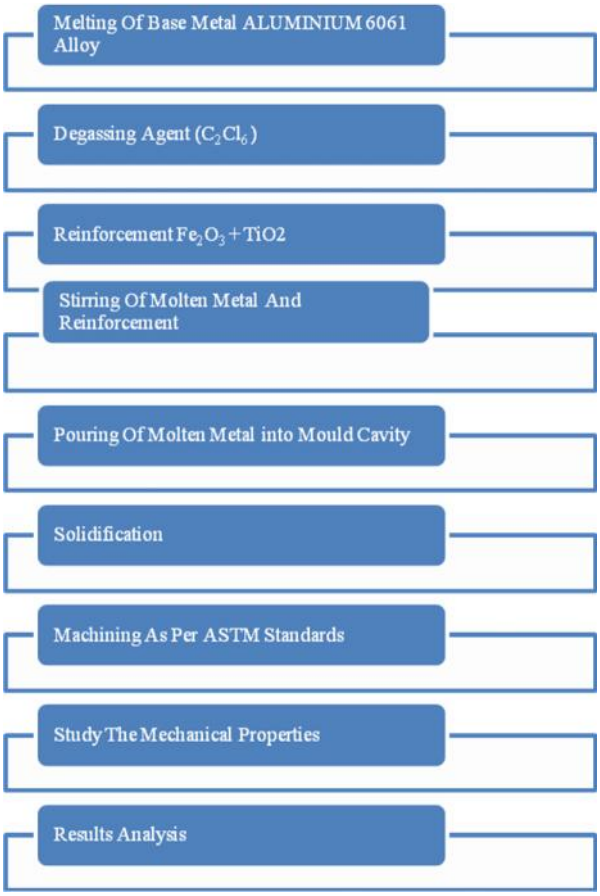


Fig-1: bottom pouring stir casting machine

D. Methodology:



E. Process parameters:

Table: 2 process parameters

PROCESS PARAMETERS	REINFORCEMENT VOLUME FRACTION		
	1%	2%	4%
Stirrer speed	300 rpm	300 rpm	300 rpm
Stirrer material	Stainless steel	Stainless steel	Stainless steel
Stirring time	5 min	5 to 10 min	5 to 10 min
Reinforcement temperature	400 °C	400 °C	400 °C
Matrix material with temperature	750°C	750°C	750°C
Furnace temperature	800°C	800°C	800°C
Die pre heating temperature	350 °C -600°C	350 °C -600°C	350 °C -600°C

Fig – 2: Three Fingers Die

IV. EXPERIMENTALSETUP

1. Tensile Strength:

After the fabrication of composites The segment are prepared as per ASTM standards. The tensile tests are conducted on universal strength testing machine. The results of tensile tests are shown below.

Fig- 3: Tensile testing Specimen.

2. Compression Strength:

The piece are prepared for compression test as per machine specifications are in the ratio of $\frac{l}{d}$. The compressive test are conducted on universal testing machine. The results of compressive test are shown below table (3).

Fig – 4: Universal testing machine

3. microstructure:

Microstructural observation were carried out on 10 *10 mm dimensioned samples .The samples were shiny metallographically and etched suitably. Keller's reagent was used for etching the samples of the aluminium alloy and composites. Microstructural identification of the samples was carried out using Inverted computerized microscopy.

Fig – 5: microscopy testing machine

1. density:

Density is defined as, mass of a substance per unit volume. Mathematically it is donated as mass divided by volume. Theoretical density of aluminum6061 is2.7 g/cm^3. The experimental density for each composite was evaluated by weighing the test sample with an tolerable or accurate weighing machine . Experimental density of composites was determined by water displaced technique by using this equation.

$$\rho_{Exp} = \frac{m}{v}$$

m- Mass of the specimen
v- Volume of water displaced

Fig – 6: Density measuring instrument

2. Hardness:

brinell hardness & Vickers Hardness is determined by forcing a hard metal of a specified dimensions under a specified pressure into the surface of a composite and finding the dimensions of the produced indentations and left after the experiment. The specimen is prepared as per machine specifications.

Fig – 7: Hardness measuring instruments

V. RESULTS AND DISCUSSIONS

A. TensileStrength:

The below chart, shown the relation between ultimate tensile strength and volume fraction of reinforcements of fabricated composites. From this experiments results, it is observed that the ultimate tensile strength of AMCs is greater than unreinforced Al. increasing of reinforcement wt % the ultimate tensile strength of fabricated composites will be increased. And by observing three different reinforcement fraction the maximum strength was observed at 4% of reinforcement.

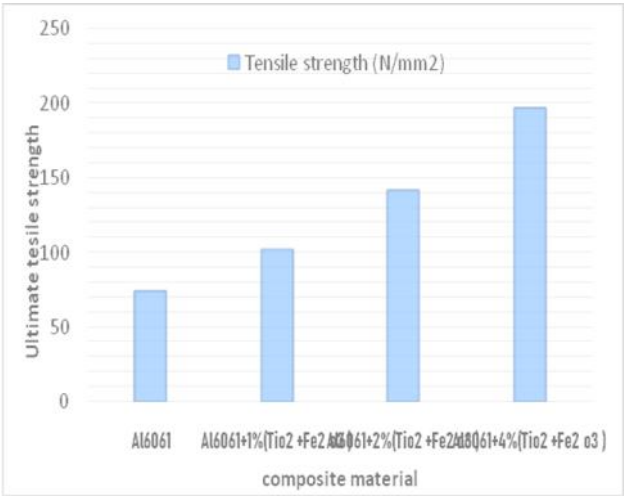


Fig – 8: Ultimate tensile strength graph Vs composite material

Figure clearly shows the variation of the ultimate tensile strength of the composites with increase in there inforcement concentration in them. The Compressive strength values of AMCs with varying wt.% of Fe2o3 and Tio2reinforcements.it was recorded with the addition of 1% of Fe2o3 and Tio2 and tensile strength of 101.35(N/mm2) with an increment of 37.2 % was observed and with 2%,4% of Fe2o3 and Tio2 and Compressive strength of composites were recorded with the values of 141 and 196(N/mm2)

B. Compression Strength:

From these results, it is observed that the compressive strength of AMCs is better than unreinforced material. Finally in this test the maximum breaking point and maximum displacement occur at 4% of reinforcement so the best compressive strength was observed at this reinforcement fraction.

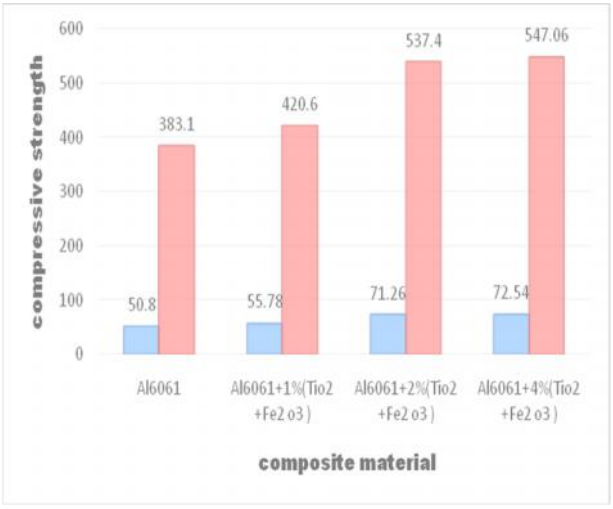


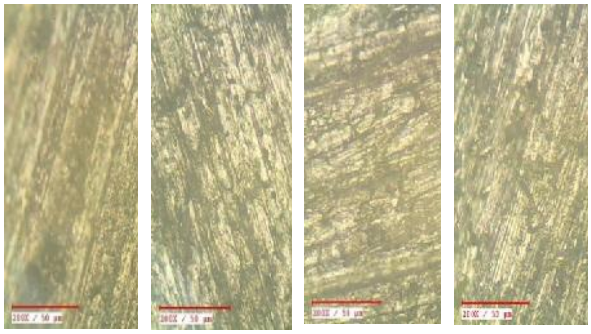
Fig – 9: compression strength graph Vs composite material

Figure clearly shows the variation of the compressive strength of the composites with increase in there inforcement concentration in them. The Compressive strength values of AMCs with varying wt.% of Fe2o3 and Tio2 reinforcements.it was recorded with the addition of 1% of Fe2o3 and Tio2 and compressive strength of 420.6 (N/mm2) with an increment of 9.7 % was observed and with 2%,4% of Fe2o3 and Tio2 and Compressive strength of composites were recorded with the values of 537.4 and 547.07(N/mm2)

C. Microstructure:

A computerized inverted metallurgical microscope with all accessories for analyzing the microstructure images was utilized to evaluate the microstructure of the metal matrix hybrid composites. Traditional enhance polishing of the

routines following by the etching with solutions of 10ml hydrochloric acids, 10ml methanol and 5ml of hydrofluoric acid was utilized to preparation of the samples before microscopic evaluation.



Al6061 Al6061+1 %(Tio2 +Fe2 o3) Al6061+2 %(Tio2 +Fe2 o3) Al6061+4 %(Tio2 +Fe2 o3)

Fig-10: Microstructures with variation of reinforcements

The microstructure of the developed composites material was investigated with the help of inverted metallurgical microscope. The microstructure of produced aluminum alloy shows primary Al dendrites and secondary intermetallic phases throughout the dendrites. The Fe_2o_3 and TiO_2 particles are noted to be uniform distribution within the metallic matrix.

D. density:

the below graph shows density and volume fraction of reinforcement and the density of AMCs is Higher than the unreinforced Al material. This result shows that the density of composite material will be increasing while increasing the reinforcement fraction because of density of Fe_2o_3 and TiO_2 is higher than the matrix material.

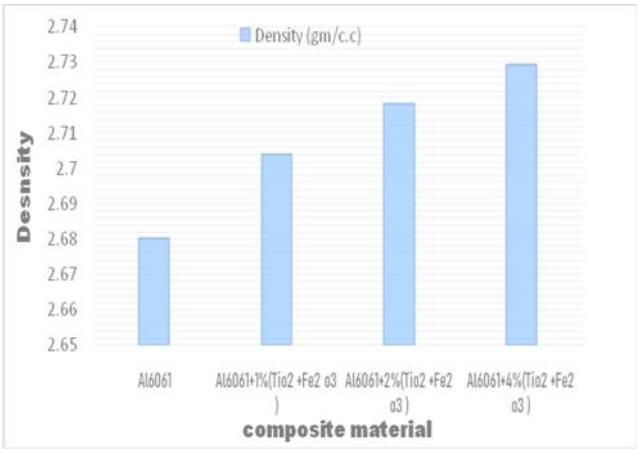


Fig – 11: Density results Vs composite material

E. Hardness:

Below chart shows, the relation between Hardness and wt. % of reinforcements of fabricated composites. From the Hardness results, it is observed that the Hardness of AMCs is greater than unreinforced Al. Increasing of Hardness in AMCs can be attributed due to the bonding between reinforcements and the basemental.From the obtained results it is observed that hardness value is increasing with increase of reinforcement material.

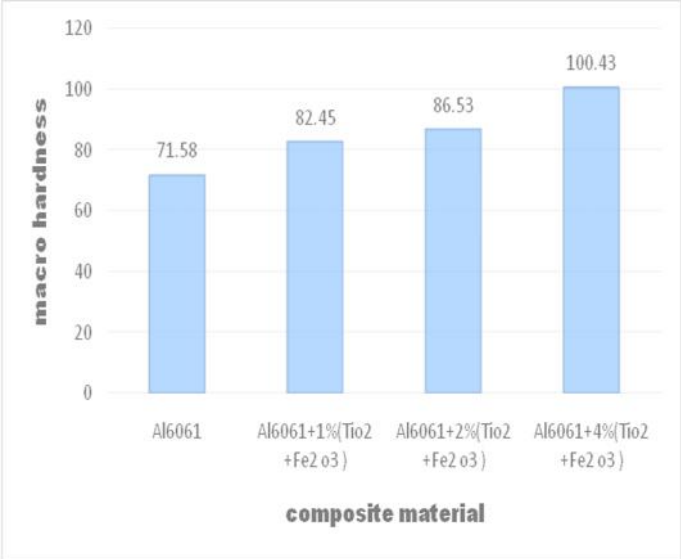


Fig – 12: Brinell hardness graph.

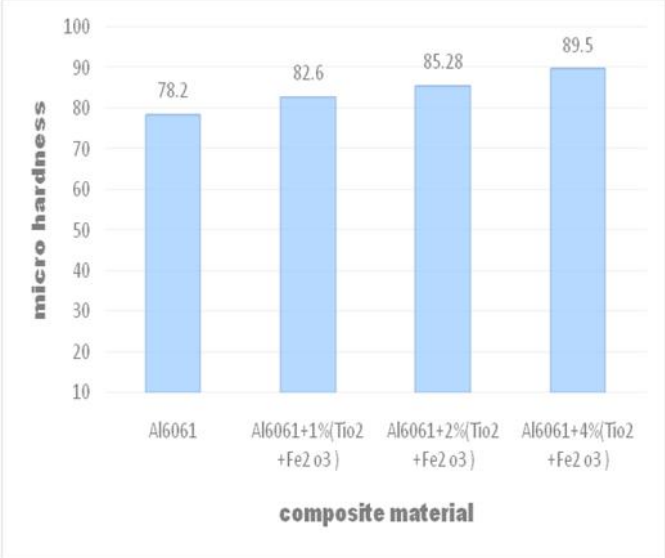


Fig – 13: Vickers hardness graph Vs composite material.

Figure clearly shows the variation of the Hardness of the composites with increase in there inforcement concentration in them. The macro and micro hardness values of AMCs with varying wt. % of Fe2o3 and Tio2

reinforcements. it was recorded with the addition of 1% of Fe2o3 and Tio2 and Hardness of 82.6(Hv) with an increment of 5.6 % was observed and with 2%,4% of Fe2o3 and Tio2 and Compressive strength of composites were recorded with the values of 85.28 and 89.5(HV)

VI. CONCLUSIONS

Hybrid metal matrix composites Al-6061-T6 and ferric oxide and titanium dioxide were fabricated using the stir casting method with four different weight ratios of Tio2 particles (Three different samples were taken (0.5+0.5)%,(1+1)%,(2+2)%. The following conclusions from the experiments were obtained

- The density of the fabricated composites increased with an increase in Fe2o3 and Tio2.content in comparison with Al−6061 alloy.
- The hardness of the composites increases with increase in Fe2o3 and Tio2 content compared with the matrix. The maximum hardness attained at 2% Tio2+2Fe2o3% in the fabricated composites.
- The compressive strength of the composites increases with increase in Fe2o3 and Tio2 content compared with the matrix. The maximum compressive strength attained at 2%Tio2+2Fe2o3% in the fabricated composites.
- The Brinell hardness of the composites increases with increase in Fe2o3 and Tio2 content compared with the matrix. The maximum hardness attained at (2%Tio2+2Fe2o3%) in the fabricated composites.
- The Tensile strength of the composites increases with increase in Fe2o3 and Tio2 content compared with the matrix. The maximum Tensile strength attained at 4% in the fabricated composites.

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