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Mechanical characterization of Al-Fe composite

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ABSTRACT

Aluminum MMCs are preferred to other conventional materials in the fields of aerospace, automotive and marine applications owing to their improved properties like high strength to weight ratio, good wear resistance etc. In the present work, an attempt has been made to synthesize metal matrix composite using Al6061 as matrix material reinforced with ceramic Fe_3O_4 particulates using liquid metallurgy route in particular stir casting technique.

Aluminum matrix composites reinforced with Iron oxide particles gives superior mechanical properties. And are used in several demanding fields like automobile, aerospace, defense, sports, electronics, bio-medical and other industrial purposes.

Various manufacturing processes e.g. stir casting, ultra-sonic assisted casting, compo-casting, powder metallurgy, liquid infiltration are being utilized for the production of the aluminum matrix composites. These composite materials possess improved physical and mechanical properties.

Keywords: *MMC, Stir Casting, Al 6061, Fe_3O_4.*

1. INTRODUCTION

Conventional monolithic materials have limitations to achieve combinations of strength, stiffness and density, in order to overcome these shortcomings, intermetallic compounds are gaining importance. Composite material is a material consisting of 2 or more physically or chemically distinct phases. The composites are generally superior in characteristic than those of each individual components. Usually the reinforcing component is distributed in matrix component. [1]

Iron is most commonly found impurity in aluminum. It has a high solubility in molten aluminum and is therefore easily dissolved in the liquid state of aluminum, however its solubility in the solid state is very low (~0.04%). The low solubility of iron in solid state is accompanied by decreased ductility as a result of the formation of intermetallic phases like FeAl and Fe_3Al. The intermetallic phases increase the strength of the aluminum alloy. [2]

To meet the ever increasing engineering demands of modern technology, metal matrix composites are one of reliable source. Composite material is one of the reliable solutions for such requirement. In composites, materials are combined in such a way as to enable us to make better use of their parent material while minimizing to some extent the effects of their deficiencies. The simple term composites' gives indication of the combinations of two or more material in order to improve the properties. In recent years, materials development has shifted from monolithic to composite materials for adjusting to the global need for reduced weight, low cost, quality and high performance in structural materials. [3]

2. EXPERIMENT DETAILS

2.1 Material

The base material used in the experimental investigation is commercially available pure aluminum. The iron powder used as the composite material of size 44-48μm or 300mesh size. The percentage by weight Aluminium-6061 composition is as shown in Table-1.

Table-1: Al 6061 Composition

Material	Percentage by Weight
Silicon	0.4-0.8
Iron	0.7
Copper	0.15-0.4
Manganese	0.15
Magnesium	0.8-1.25
Chromium	0.04-0.35
Zinc	0.25
Titanium	0.15
Aluminum	95.85-98.56

2.2 Sample preparation

The Al Fe intermetallic composite is prepared by stir casting route. Take 2kg of Al 6061 alloy pieces and desired amount of iron powder particles. Commercially pure aluminum is melted in an electric furnace. The melt temperature is raised up to 700°C and it is degassed by purging hexachloroethane tablets. Then the melt is stirred using mechanical stirrer. The stirring is maintained between 5-10minutes at an impeller speed of 200rpm. At the same time, the mould is preheated to avoid the shrinkage of casting material.

2.3 Determination of Tensile and Compression Strength Properties

The tensile testing of the composite is done on the universal testing machine (UTM) Standard specimens with specified gauge length is used to evaluate the ultimate tensile strength. The comparison of properties of the composite material is done with the commercially available pure aluminum. The compression test of the composite is also done on UTM. Standard specimen with 20mm diameter and 30mm length were used to evaluate the compression strength.

2.4 Wear and hardness

Hardness Test of the specimen was done on Brinnel hardness testing machine. The Brinnel test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by preload. Wear test is a simple test for evaluating the abrasion or wear resistance of the test specimen. A pin on disc wear testing machine was used for this purpose.

3. RESULTS AND DISCUSSION

3.1 Tensile Test

From tensile test results, the variation of UTS with the increase in iron percentage is as shown in Graph-1. As the weight percentage of iron increases, the tensile strength increases gradually. The tensile strength increases 131.2MPa, 144.6MPa and 163.2MPa for 2.5, 5 and 7.5wt% of addition of Fe. This indicates that as the addition of Fe increased the composite turns to become brittle and percentage of elongation decreases. Figure-1, 2 represents the dimensions of the tensile specimen in mm and specimen after the test respectively.

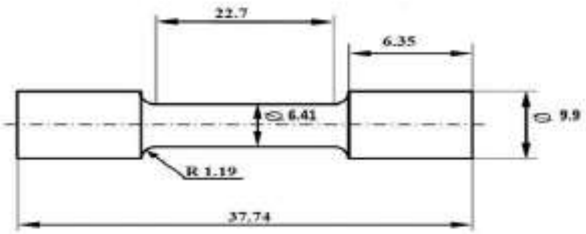
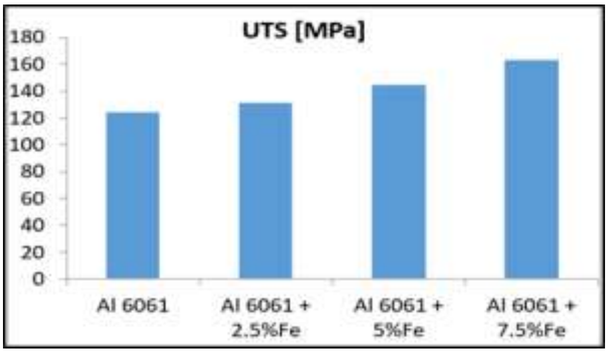


Figure-1 Tensile specimen dimensions in mm

Figure-2 Tensile specimen after the test



Graph-1 Ultimate Tensile Strength of the sample

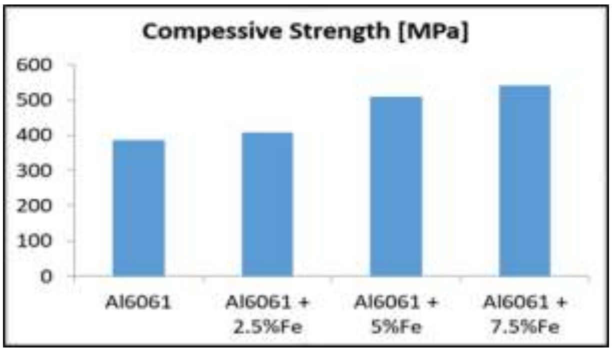
3.2 Compression Test

A compression test is a very common testing method that is used to establish the compressive force or crush resistance of a material and the ability of the material to recover after a specified compressive force is applied and even held over a defined period of time. Figure-3 and Figure-4 represent the specimen before and after the test respectively.

Figure-3 Specimen before the test

Figure-4 Specimen after the test

The variation of Compressive strength is illustrated in the Graph-2.



Graph-2 Compression strength of the sample

3.3 Wear Test

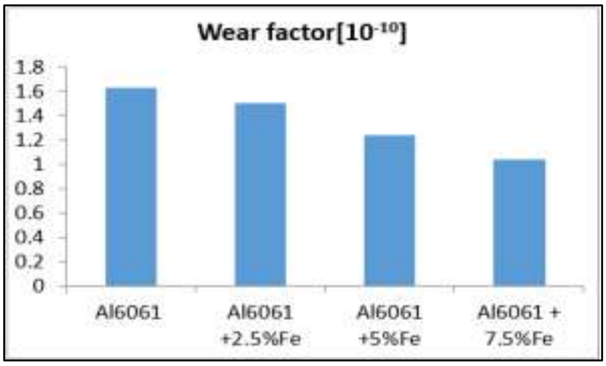
From Graph-3, it is clear that the wear factor of AlFe intermetallic decreases as weight percent of iron powder increases. This is because as the weight percentage of iron increases, the hardness of the intermetallic composite enhances. Table-2 illustrates the parameter of the test. Figure-5 represents the wear specimen and the machine used for testing the wear is as shown in Figure-6.

Table-2: Testing parameter

Load	2kg
Speed	400-450rpm
Test Duration	15mins
Track radius	35-40mm

Figure-5 Wear specimen

Figure-6 Wear testing machine

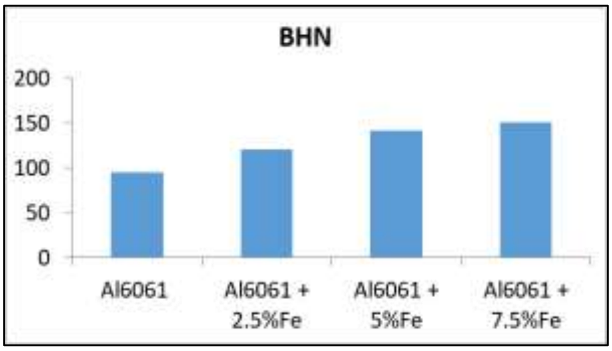


Graph-3 Wear factor of the sample

3.4 Hardness Test

As the percentage of iron increases, the strength of the aluminum enhances. For pure Al 6061, hardness is 95 BHN, for 2.5%wt of iron in Al 6061 hardness increases to 121 BHN, similarly for 5%wt of iron in Al 6061 hardness is 141 BHN and for 7.5%wt of iron in Al 6061 hardness increases to 151 BHN. Graph-4 shows the variation of hardness with an increase in %wt of iron. Figure-7 represents the Hardness Testing machine.

Figure-7 Hardness testing machine



Graph-4 Hardness Number of the sample

4. CONCLUSION

The following conclusion may be drawn from the present work:

- We can use iron powder for production of aluminum intermetallic composite.
- The stir casting method used to prepare the composite could produce a uniform distribution of iron powder.
- Iron powder (44-48μm) up to 7.5% by weight can be added successfully to commercially pure aluminum by stir casting route to produce a composite.
- The hardness of Al 6061 increases with the increase in the addition of iron powder.
- The ultimate tensile stress and compressive strength of the composite have increased with increase in iron content whereas the percentage of iron increases the material property of material changes from ductile to brittle.
- The wear factor decreases as the percentage of the iron content increases due to improved hardness.

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