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"Investigation of Mechanical Properties of Al 7075 with Magnesiumoxide Nano Powder Mmc"

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Abstract: *Metal Matrix Composites are posses significantly improved properties including high tensile strength, hardness, low density and good wear resistance compared to alloys or any other metals.*
In this paper the composite material is developed by reinforcing of Magnesium Oxide Nano powder in Aluminum alloy Al7075. The composites are fabricated by Stir Casting Machine. The MMC's specimens are prepared by varying the percentage of weight fraction of the reinforced particles as 5% and 10% and the remaining aluminum alloy respectively. The mechanical properties are Tensile strength, Impact Test, Hardness is proposed to investigate.
Keywords: *MMC, Stir Casting, Al 7075, MGO*

I. Introduction

Metal Matrix Composites are being increasingly used in aerospace and automobile industries owing to their enhanced properties such as elastic modulus, hardness, tensile strength at room and elevated temperatures, wear resistance combined with significant weight savings over unreinforced alloys.

The commonly used metallic matrices include Al, Mg, Ti, Cu and their alloys. These alloys are preferred matrix materials for the production of MMCs. The reinforcements being used are fibers, whiskers and particulates. The advantages of particulate-reinforced composites over others are their formability with cost advantage. Further, they are inherent with heat and wear resistant properties. For MMCs SiC, Al_2O_3 and Gr are widely used particulate reinforcements.

Compositionally, MMCs have at least two components, viz. the matrix and the reinforcement. The matrix is essentially a metal, but seldom a pure one. Except sparing cases, it is generally an alloy. The most common metal alloys in use are based on Aluminum and Titanium. Both of them are low density materials and are commercially available in a wide range of alloy compositions.

The reinforcements for MMCs can be broadly divided into five major categories, viz. Continuous fibres, discontinuous fibres, whiskers, wires and particulates. Except the wires being metals, the reinforcements are generally ceramic; which can be oxides, carbides and nitrides which are used because of their excellent combination of specific strengths and stiffness at both ambient and elevated temperatures.

MMCs offer designers benefits as they are particularly suited for applications requiring good strength at high temperature, good structural rigidity, dimensional stability and light weight. The present day trend is towards safe usage of the MMC parts in the automobile engines, which work particularly at high temperature and pressure environments. The increase in demand for lightweight, stiff and strong material has led to the development of MMCs reinforced with ceramic dispersions.

These mmcs possess excellent mechanical and tribological properties and are considered as potential engineering materials for various tribological applications. Several researchers have worked on sliding wear mechanism of mmcs reinforced with ceramic particulates like sic, al_2o_3 and garnet particles etc. And have observed improvement in wear and abrasion resistance, reviewed the world-wide upsurge in metal-matrix composite research and development activities with particular emphasis on cast metal-matrix particulate composites.

II. Selection of Materials:

Work Materials which are used in the experiment.

- ❖ Matrix Material
- Aluminium (Al7075)
- ❖ Reinforcement Materials
- Magnesium Oxide Nano powder

II.I. Matrix Material:

II.I.I. Aluminum (Al7075):

The matrix material to be used was chosen as Al7075 which is a precipitation hardened aluminum alloy, containing zinc, magnesium, copper, and chromium as its major alloying elements. It has good mechanical properties and it is strong with strength comparable to many steels, has good fatigue strength and less resistance to corrosion and many others.

Table: 1 Chemical Composition of Aluminum 7075

Element	Percentage	Element	Percentage
Si	0.4	Cr	0.28
Cu	2	Ni	-
Mg	2.9	Zn	6.1
Mn	0.3	Ti	0.2
Fe	0.5	Zr	-
		Al	Remainder

Table: 2 Properties of Al7075

Properties	Density	Melting Point	Fatigue Strength	Tensile Strength	Hardness
Al 7075	2.8 g/cc	483^{0} C	160 MPa	220 MPa	60

II.I.II. Reinforcement Material:

Magnesium Oxide is selected as Reinforcement. It is physically and chemically stable at high temperatures. It has two attributes: high thermal conductivity and low electrical conductivity. Magnesium oxide (MgO) has elastic modulus of approximately 300GPa, shear modulus of 122 GPa and CTE (coefficient of thermal expansion) of 12 μm/m-^{o}C. The MgO nanoparticles have high surface reactivity and high chemical and thermal stability, which make MgO a hopeful material for applications in fields of sensors, semiconductors, etc.

Fig: 1. Magnesium Oxide Nano Powder

Table: 3 Chemical Composition of Magnesium Oxide Nano Powder

Element	**Content %**
Magnesium	60.29
Oxygen	39.67

Table: 4 Properties of Magnesium Oxide Nano Powder

Properties	**Density**	**Melting Point**	**Boiling Point**
Mgo	3.58 g/cc	2852^{0}C	3600^{0}C

II.II. Rule of Mixtures:

Density: dc = dm*Vm + df*Vf

Where,

- dc, dm, df – densities of the composite, matrix and dispersed phase respectively;

Vm,Vf – volume fraction of the matrix and dispersed phase respectively.

III. Experimental Procedure:

Stir-casting is the simplest and most commercial method of production of MMCs. This approach involves mechanical mixing of the reinforcement particulate into a molten metal bath and transferred the mixture directly to a shaped mould prior to complete solidification. In this process, the crucial thing is to create good wetting between the particulate reinforcement and the molten metal.

The stir casting technique was used to fabricate the composite specimen as it ensures a more uniform distribution of the reinforcing particles. This method is most economical to fabricate composites with discontinuous fibres or particulates. In this process, matrix alloy (Al 7075) was first superheated above its melting temperature. Then keep the matrix alloy in the semisolid state. At this temperature, the preheated Mg particle of 5%, 10% (by weight) were dropped into the slurry and mixed using a graphite stirrer.

The composite slurry temperature was increased to fully liquid state and automatic stirring was continued to about five minutes at an average stirring speed of 300-350 rpm under protected organ gas. The Mg particles help in distributing the particles uniformly throughout the matrix alloy. The melt was then superheated above liquids temperature and finally poured into the cast iron permanent mould for testing specimen.

Fig: 2 Melting of Al7075 in Stir Casting

III.I. Important Parameters Used in stir casting.

III.I.I. Particulate Preheating Temperature:

Preheating of particulate is necessary to avoid moisture from the particulate otherwise chances of agglomeration of particulate occurs due moisture and gases. The preheated temperature in a furnace is made up to 800^0C and maintained at that temperature before mixing with Aluminum melt. Along this MgO particles were heated to form a oxide layer on the MgO particles which make it chemically more stable and by the oxide layer formation wet ability will increase so particles will effectively embedded in aluminum matrix and will result in less number of porosities in casting.

III.I.II. Stirring Speed:

In stir casting process stirring speed is very important parameter for consideration. In the process stirring speed was 500 rpm which was effectively producing vortex without any spattering. Stirring speed is decided by fluidity of metal if metal having more fluidity then stirring speed will be low. It is also found that at less speed, dispersion of particulates is not proper because of ineffective vortex.

Fig: 3 Stir Casting Equipment

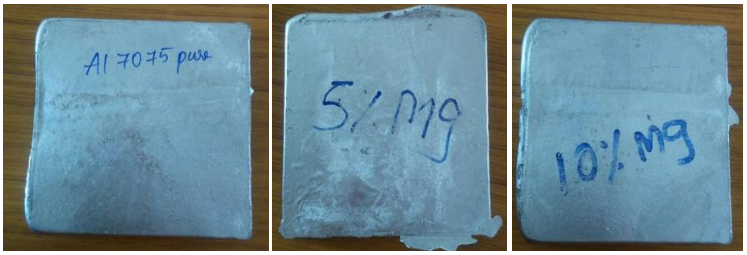

Fig: 4. Casted Specimens

IV. Experimental Details:

The Mechanical Properties are considered on Al7075 reinforce with 5%, 10% Magnesium Oxide (MgO) subjected based on tests of the specimens.

IV.I. Tensile Strength:

Fig: 5. Tensile Test Specimen

IV.II. Hardness Test:

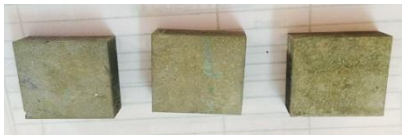

Fig: 6 Hardness Test Specimens

IV.III. Impact Test:

Fig: 7 Impact Test Specimen

V. Results & Conclusions:

V.I. Tensile Test:

Specimen	Composition	Ultimate Tensile Strength N/mm2	Ultimate Load KN
A	100% Al 7075	50.887	5.220
B	95% Al 7075 + 5% MgO	137.042	13.500
C	90% Al 7075 + 10% MgO	197.211	19.800

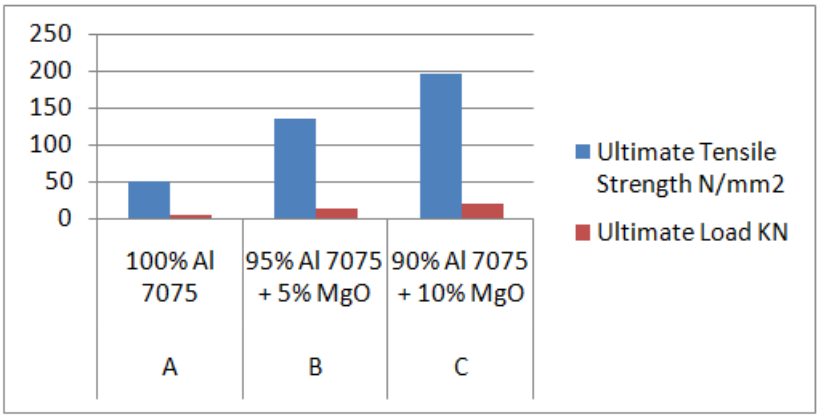

Fig:8. Graph Details of Tensile Test

V.II. Charpy Impact test:

Specimen	Composition	Observed Values (Joules)
A	100% Al 7075	2
B	95% Al 7075 + 5% MgO	2
C	90% Al 7075 + 10% MgO	2

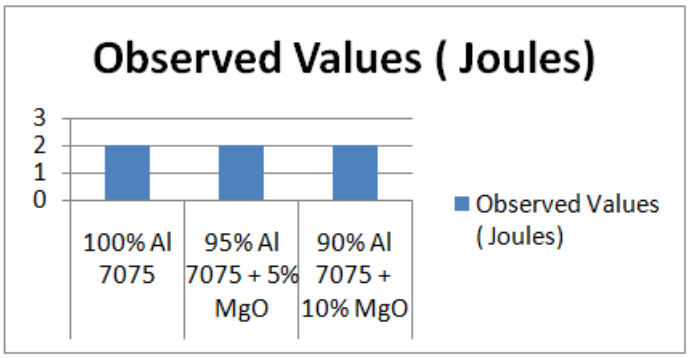

Fig:9. Graph Details of Impact Test

V.III. Hardness Test:

Specimen	Composition	Observed values in HBW			
		1	2	3	Avg
A	100% Al7075	96.1	97.2	97.2	96.8
B	95% Al 7075 + 5% MgO	91.7	92.8	91.7	92.1
C	90% Al 7075 + 10% MgO	99.5	101	99.5	100

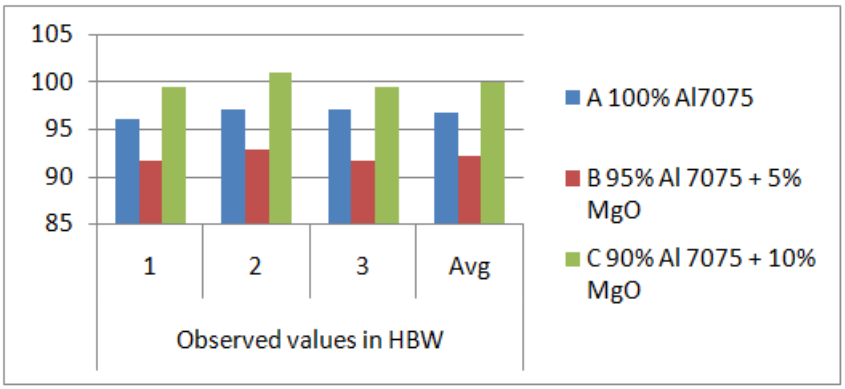

Fig:10. Graph Details of Hardness Test

VI. Conclusions:

1. The tensile properties of composite were considerably improved by the addition of Magnesium Oxide particles, however tensile value of the composite was much higher than the unreinforced nano particles.
   - At 100% Al Ultimate load is 5.220KN, Ultimate tensile strength is 50.887N/mm^2
   - At 95% Al Ultimate load is 13.500KN, Ultimate tensile strength is 137.042N/mm^2
   - At 90% Al Ultimate load is 19.800KN, Ultimate tensile strength is 197.211N/mm^2
2. The distribution of nano-particles measured by using Stir casting was found as a suitable method for fabrication of this kind of composite and also hardness of fabricated composite value also improved
   - At 100% Al hardness value is 96.83
   - At 95% Al hardness value is 92.07
   - At 90% Al hardness value is 100

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