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A STUDY ON MECHANICAL PROPERTIES OF ALUMINA REINFORCED AL6061 COMPOSITES PROCESSED THROUGH STIR CASTING

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***Abstract:* - Composite materials have been outperforming the monolithic materials over the past few years by their efficient properties like, low cost, high performance, low weight, high strength etc. Among all the composites, Aluminum metal matrix composites have been finding wide range of applications in household appliances, aerospace industries etc. by providing economic and environmental benefits. The ductile material Aluminum 6061as matrix material is reinforced with alumina (Al_2O_3). This MMC provides flexibility to have a feasible material composition with the combined attributes of metal and ceramic to suit our necessary application. The present investigation has been carried out to study the effect of weight percentage of constituents in processing aluminum based composite material being reinforced by the micro material, Al_2O_3. Test samples are prepared using Stir casting technique. An experimental analysis is done to find flexural strength, compressive strength and hardness by varying the weight percentage of alumina in Al6061 composite**.

Index Terms: -MMC, Al_2O_3, Composite, Al6061 alloy**.**

1. INTRODUCTION

1.1 Composite

A combination of two or more materials (reinforcement, resin, filler, etc.),differing in form or composition on a macro scale. The constituents retain their identities, i.e.., they do not dissolve or merge into each other, although they act in concert. Normally, the components can be physically identified and exhibit an interface between each other.

One constituent is called **reinforcing phase** and the one in which the reinforcing phase is embedded is called **matrix**.

Aluminum Metal Matrix Composites

Aluminum alloys are preferred engineering material for automobile, aerospace and mineral processing industries for various high performing components that are being used for varieties of applications; owing to their lower weight and excellent thermal conductivity properties. Among several series of aluminum alloys, heat treatable Al6061 and Al7075 are much explored, among them Al6061alloy are highly corrosion resistant, exhibits moderate strength and finds much applications in the fields of construction, automotive and marine applications. Aluminum alloy 7075 possesses very high strength, higher toughness and are preferred in aerospace and automobile sector. Due to their high strength, fracture toughness, wear resistance and stiffness, the composites formed out of aluminum alloys are of wide interest.

Aluminium and its alloys have attracted most attention as base metal in metal matrix composites. Aluminium MMCs are widely used in aircraft, aerospace, automobiles and various other fields. The reinforcements should be stable in the given working temperature and non-reactive too. The most commonly used reinforcements are Silicon Carbide (SiC) and Aluminium Oxide (Al2O3). SiC reinforcement increases the tensile strength, hardness, density and wear resistance of Al and its alloys. The particle distribution plays a very vital role in the properties of the Al MMC and is improved by intensive shearing. Al2O3 reinforcement has good compressive strength and wear resistance. Boron Carbide is one of hardest known elements. It has high elastic modulus and fracture toughness. The addition of Boron Carbide (B4C) in Al matrix increases the hardness, but does not improve the wear resistance significantly. Fibers are the important class of reinforcements, as they satisfy the desired conditions and transfer strength to the matrix constituent influencing and enhancing their properties as desired. Zircon is usually used as a hybrid reinforcement. It increases the wear resistance significantly. In the last decade, the use of fly ash reinforcements has been increased due to their low cost and availability as waste by-product in thermal power plants. It increases the electromagnetic shielding effect of the Al MMC.

2. OBJECTIVE OF THE WORK

In this thesis, experimental analysis is done to find flexural strength, compressive strength and hardness by varying the weight percentage of alumina in Al6061 composite.

3. EXPERIMENTAL PROCEDURE

3.1. Materials for Experiments

Alumina Reinforced Al6061composites were manufactured by using Stir Casting Method.Al6061 ingots are as a matrix and alumina as reinforcement. The properties of as supplied Al6061 are as shown in Table 3.1.

Table.3.1: Composition of Al6061

Alloy element	**Al**	**Mg**	**Si**	**Cu**	**Zn**	**Ti**	**Mn**	**Cr**	**Others**
% by weight	Balance	0.8 - 1.2	0.4 - 0.8	0.15 - 0.40	Max. 0.25	Max. 0.15	Max. 0.15	0.04 - 0.35	0.05

3.2 Production of Composites

The fabrication of metal matrix composites through liquid state processing is a cheap and best technique for the complex shaped objects. But in most of the casting processes the dispersion of reinforcement content in the matrix is a complex task due large surface-to volume ratio, poor wettability and cluster formation. The wettability affects the interfacial bonding strength between the matrix and reinforcement and also the distribution of load transfer from matrix to the reinforcement. Due to the formation of clusters the composite become brittle and cause for the reduction of mechanical properties. A good dispersion of matrix and reinforcement was possible only with the breakup of cluster formation. Hence the components are prepared by Stir Casting method. Fig.4.1 shows the schematic diagram of experimental set-up used for manufacturing of aluminum matrix composites for the present investigation.

(a)

(b) Fig.3.1: Experimental Setup

Table 3.2: Specifications of experimentation setup

Description	**Specification**
Chamber size	20" dia and 15" height
Crucible of graphite material	1.0kg capacity
Power rating	3840W
Temperature control	Digital temp
Type of door	Top opening

3.3 Manufacturing of Al_2O_3/Al6061 MMCs

The process was started by feeding the Al6061 alloy ingots into the graphite crucible and heated to a temperature of 100^0C above of its melting point. The quantity of Aluminium (6061) alloy and alumina(Al2O3) particles required to produce composites having 3, 6,9,12,15 and 18wt.% alumina were evaluated using charge calculations. The stirring operation was performed at a speed of 300 rpm for10 minutes to help improve the distribution of the alumina particles in the molten AA6061.An external temperature probe (thermocouple) was utilized to monitor the temperature of the furnace. The molten composite was then cast into the prepared die. Unreinforced AA 6061 were also prepared by casting for control experimentation.

Thus after efficient processing, a higher casting temperature of 760^0C was used to ensure the flowability inside the graphite mold. After proper stirring processing, the liquid composite was poured into the die and was allowed to solidify in the ambient atmosphere. Fig.3.2 presents the steel cavity and solidified composite. For comparison, 0 wt. %Al_2O_3 sample was also prepared with the Stirring Casting. The specifications of experimentation setup used to prepare the MMCs are given in Table 3.2 and the casting parameters considered are summarized in Table 3.3.

Fig. 3.2: Solidified Al_2O_3 reinforced Al6061composi

Table 3.3: Details of parameters in Stir Casting process

Description	**Specification**
Stirring Temperature	750^0C
Stirring Speed	300rpm
Stirring Time	10 min
Length of Stirrer	1.5m

4. EXPERIMENT RESULTS

During the experiment, when Al_2O_3 particles were added into the molten alloys they tended to float on the surface of the melt, even though Al_2O_3 has a slightly smaller specific density than that of the molten aluminum alloy. Possible causes might be the high surface tension of the melt and the poor wetting between the particles and the melt. By applying Stirring Action the particles are trapped into the melt and mixed efficiently.

4.1 Flexural Strength

Fig.4.1: Flexural testing setup

The Flexural testing specimens of fabricated composites were machined according to ASTM standards. The composite were tested for Flexural strength by using FIE make UTE100 model universal testing machine at room temperature. The Flexural strength results of the samples are shown in Fig.4.1. These results reveal that, effect of Al_2O_3 percentage content lead to decrease the interspatial distance between Alumina and matrix grain, which reduces the number of dislocations at the grain boundaries in the microstructure. Hence, the enhancement in the Flexural strength was obtained than that of the matrix alloy as presented in the Fig.4.2. The enhancement of the Flexural strength was possible due the strong bonding strength between the reinforcement and matrix.

Table.4.1: Flexural strength variation with the addition of Al_2O_3

% of Reinforcement	Flexural Strength(MPa)
0	54
3	52
6	64
9	72
12	53
15	45
18	34

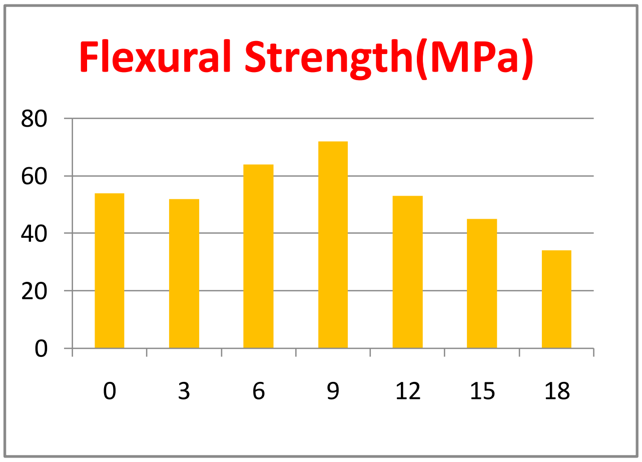

Fig. 4.2: The variation of Flexural strength with Al_2O_3 addition

4.2 Compressive Strength:

(a)

(b)

Fig. 4.3: Compressive Strength testing Setup

Table.4.2: Compressive strength variation with the addition of Al_2O_3

Wt.% of Reinforcement	Compressive Strength(MPa)
0	92
3	103
6	117
9	126
12	108
15	95
18	84

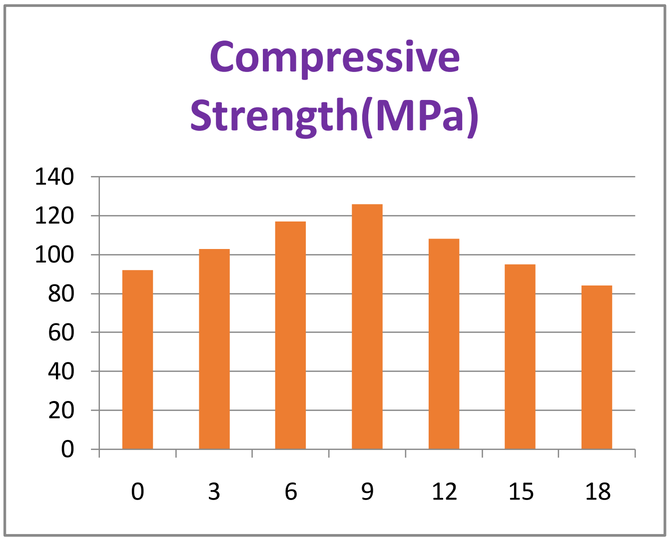

Fig.4.4: Effect of Al_2O_3 content on compressive strength

By the addition of Alumina, the hardness of the Composites was increased due to reinforced ceramic particles bonded with the matrix and dislocations were reduced.

5.3 Hardness

(a) **(b)**

Fig.4.5: Hardness Testing machine

Table 4.3: The Hardness Values Obtained

Wt% of Reinforcement	BHN
0	98
3	109
6	127
9	134
12	112
15	94
18	83

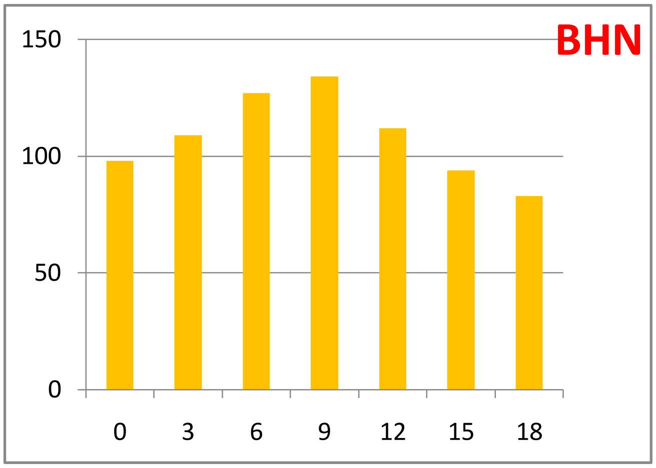

Fig.4.6: Effect of Al_2O_3 content on hardness

Fig.4.6 shows the hardness test results of the fabricated AMMCs according to ASTM standards using Brinell's hardness tester. In order to eliminate the occurrence of the particle segregation to the test zone, totally six measurements were taken at different regions on each specimen. Hardness of all variety samples of the composites was observed greater than the hardness of Al6061 matrix alloy which also proper bonding between matrix and reinforcement. The enhancement of hardness values was possible by the addition of high content of reinforcement due to the presence of hard ceramic phase in the matrix which exhibits a higher resistance to indentation. However, the further additions of beyond $Al_2O_3$9 wt.%, the hardness and Flexural strength were gradually reduced due the behavior of more brittleness. Therefore, experimentation in this research was confined to 9% of Al_{2O3} reinforcement.

5. CONCLUSION

The composite samples of Al_2O_3 reinforced Al6061 alloy have been fabricated with the dispersion of different percentage contents. The mechanical tests were conducted on the specimens. From the experimental results the following conclusions were drawn:

- The presence of Al_2O_3 leads to significant improvement in Flexural strength, Compression and hardness but decrease in ductility. The Flexural Strength, ultimate Compressive strength was increased approximately by 33%, 36% for 9 wt.% Al_2O_3 respectively.
- The greater values of hardness were achieved upto 9 wt.% Al_2O_3 reinforcement. Beyond that reduction was observed.
- This indicates that the composites with Al_2O_3 are more effective than those with monolithic Aluminum alloy.

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