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EVALUATION OF MECHANICAL PROPERTIES OF AL6061 METAL MATRIX COMPOSITE REINFORCED WITH FUSED ZIRCONIA ALUMINA

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ABSTRACT

The present study deals with the evaluation of mechanical properties of aluminium alloy (Al6061) metal matrix composites reinforced with fused zirconia alumina (ZA-40) bonded abrasive particles which were fabricated by stir casting method. The sample specimens were prepared by varying the percentage of weight fraction of reinforced particles as 5,10,15 and the remaining aluminium alloy respectively. The mechanical properties were analysed. The evaluation of mechanical properties indicates variations in tensile strength, hardness and impact strength with respect to composite combinations. From the experimental studies, the optimum weight percentage of the matrix and reinforcement on the basis of mechanical properties was found to be 90 and 10 respectively.
Keywords: metal matrix composites; fused zirconia alumina; stir casting; mechanical properties; weight percentage

INTRODUCTION

A Composite is a combination of two or more dissimilar materials having a distinct interface between them such that the properties of the resulting material are greater than the individual constituting components [1]. Composite material is composed of two or more constituent phase (i.e): matrix phase and reinforcement phase. A Metal matrix composite is one of the types of composite in which the matrix phase is predominantly a metal or a metal alloy. The metal is the base material which constitutes the major part and the minor constituents are reinforcements that can be in the form of particles, continuous and discontinuous fibers. The MMC consists of superior properties such as high strength, high stiffness, high electrical and thermal conductivity, greater resistance to corrosion, oxidation and wear comparable to base material.

Aluminium is an ideal material to be selected as a matrix as it consists of desirable properties like abundancy, low cost, low density, high strength-to-weight ratio, controlled co-efficient of thermal expansion, increased fatigue resistance and superior dimensional stability at elevated temperatures etc

SELECTION OF MATERIALS

While selecting a material, one should be very meticulous and take utmost care so that it suits the specified application. It involves both the selection of matrix as well as reinforcement materials [2].

(a) Matrix

The matrix material to be used was chosen as Al6061 which is a precipitation hardened aluminium alloy, containing iron, silicon and chromium as its major alloying elements as indicated in Table I. It has good mechanical properties and exhibits good weldability, good formability and high corrosion resistance [3].

Table I. Chemical Composition of Aluminium Al6061

Constituents	Percentage
Manganese (Mn)	0.15%
Iron (Fe)	0.70%
Copper (Cu)	0.15 - 0.40%
Magnesium (Mg)	0.15%
Silicon (Si)	0.4 - 0.8%
Zinc (Zn)	0.25%
Chromium (Cr)	0.4 - 0.35%
Others (Total)	0.05- 0.15%
Aluminium (Al)	95.8-98.6%

The properties of Al6061 were discovered by fabricating the alloy and testing under normal room temperature and subtle environmental conditions as stated in Table II .

Table II. Properties of Aluminium Al6061

Properties	Density	Melting point	Tensile strength	Brinell hardness	Izod Impact strength
Al6061	2.7 g/cc	650°C	138 MPa	75 H_B	8 Nm

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(b) Reinforcement

Fused zirconia alumina ZA-40 is selected as the reinforcement. This artificially bonded abrasive is prepared by the fusion of Zircon sand, Zirconia ore and Alumina in electric ard furnace at temperatures of 1950°C. It gives high performance and high toughness [4]. Its attractive properties are high hardness, extreme wear resistance, good durability and eutectic crystalline structure.

Table III. Composition of fused Zirconia Alumina

Zirconia (ZrO_2)	Alumina (Al_2O_3)	Silica (SiO_2)	Titania (TiO_2)	Iron oxide (Fe_2O_3)	Magnesia (MgO)
40%	59%	0.2%	0.25%	0.2%	0.35%

General properties of Fused Zirconia Alumina ZA-40 are tabulated in Table IV.

Table IV. Properties of fused zirconia alumina

Density	g/cc	4.15
Brinell hardness	BHN	1300-1650
Melting point	°C	1950
Fracture toughness	Mpa-√m	8

EXPERIMENTAL PROCEDURE

It deals with the fabrication of the metal matrix composite by stir casting method, shown in Fig. 1(a), which is best and inexpensive out of the all the available methods for producing metal matrix composites in large quantities and preferably large sizes. In this technique, the raw material of Al6061 which is in the form of round bar is placed in the graphite crucible inside muffle furnace and melted with high temperature nearing 900°C. Then fused zirconia alumina which is thoroughly mixed with 1% of magnesium to enhance wettability is preheated at 500°C and poured into the molten matrix at constant pour rate. Nitrogen is passed inside the crucible to build safe atmosphere, free from oxidation. Now the mixture is stirred with an electrical stirrer, maintained at uniform speed as shown in Fig. 1(b), for the even dispersion of reinforcement material inside the metallic matrix. Finally, the solidified composite is quenched with the help of air to reduce the settling time of the particles in the matrix after stirring is over [5]. It is then cut into respective sizes and shapes for the conduction of tests.

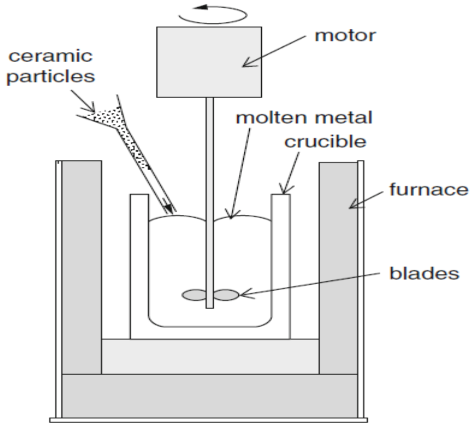

Figure 1. (a) Stir casting (b) Electrical stirrer

Table V. Composition of the test specimens

Specimens	Weight of Al6061 (in grams)	Weight of Al6061 (in %)	Weight of ZA-40 (in grams)	Weight of ZA-40 (in %)
A	2000	100	0	0
B	1900	95	100	5
C	1800	90	200	10
D	1700	85	300	15

MECHANICAL TESTS AND RESULT

The cast composite specimens are subjected to a series of mechanical tests such as tensile test, hardness test and impact test to ensure their mechanical properties [6]. The corresponding results are tabulated and indicated in graphs.

(1) Tensile test

Tension means "pulling force". Fig. 2 shows an "Universal Testing Machine" (Model:-UTE-20, Sr. No:-10/2009-4191, Max Capacity:-200KN) to determine the tensile strength of the Al6061/FZA composite specimens prepared as per Standard test methods for Tension testing 'ASTM E8/E8M-13' as indicated in Fig. 3.

Figure 2. Universal Testing Machine

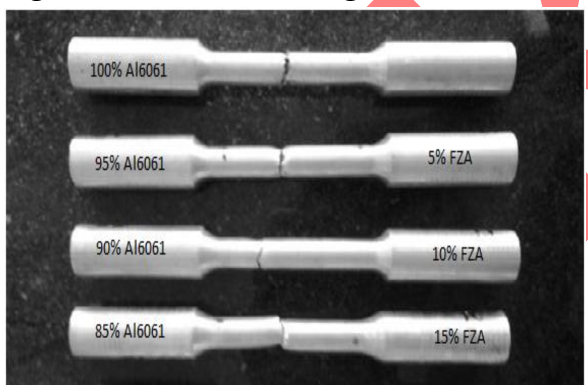

Figure 3. Tensile test specimens

After testing, the test results are tabulated in Table VI and the corresponding graph is drawn taking weight percentage on x-axis and tensile strength on y-axis as shown in Fig. 4.

Table VI. Tensile test results

Specimen	**Composition**	**Tensile strength (MPa)**
A	Al6061 (100)	138
B	Al6061 (95)+ FZA (5)	141
C	Al6061(90)+ FZA (10)	145
D	Al6061(85)+FZA(15)	143

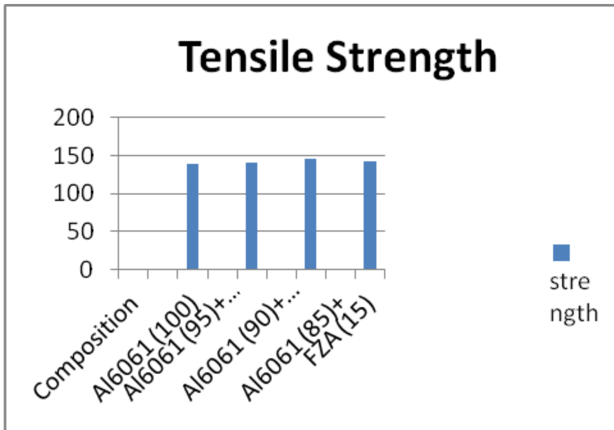

Figure 4. Tensile test results

Figure 4 shows the effect of weight fraction of fused zirconia alumina particles on the tensile strength. The results show a slow increase in tensile strength with the addition of reinforcement particles upto 10% but tend to decrease at 15% addition of reinforcement particles.

(2) Brinell hardness test

Hardness is the ability of the material to resist wear, scratching, abrasion and indentation. Brinell hardness test is done in the hardness testing machine to determine hardness number in the Al6061/FZA composite specimens prepared as per Standard test methods for Brinell Hardness testing 'ASTM E10-14'.

In the brinell test, a steel indenter, having diameter of 5 mm is forced in the surface of the composite. Standard load of 250 kgf is supplied and maintained constant for 10 seconds and then removed. Brinell hardness number is calculated from the impression of the indentation.

After testing, the test results are tabulated in Table VII and the corresponding graph is drawn taking weight percentage on x-axis and brinell hardness on y-axis as shown in Fig. 5.

Table VII. Hardness test results

Specimen	**Composition**	**Brinell Hardness (H_B)**
A	Al6061 (100)	75
B	Al6061(95)+FZA (5)	90
C	Al6061(90)+FZA(10)	96
D	Al6061(85)+FZA(15)	92

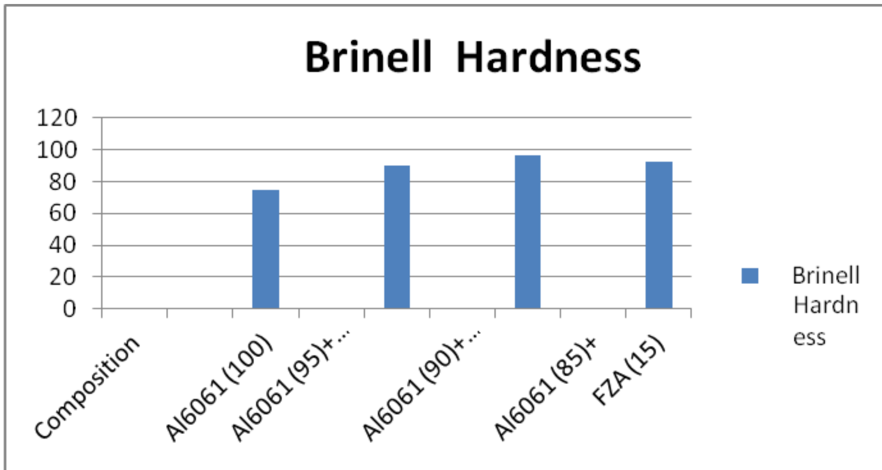

Figure 5. Hardness test results

Figure 5 shows the effect of weight fraction of fused zirconia alumina particles on the hardness. The results show a slow increase in hardness with the addition of reinforcement particles upto 10% but tend to decrease at 15% addition of reinforcement particles.

(3) Izod impact test

Impact strength is the capacity of a material to withstand blows without fracture [7]. The Izod impact test is done on the Al6061/FZA composite specimens as in Fig. 6 as per Standard test methods for notched bar tensile strain Impact test method 'ASTM E23-12C' in Impact testing machine and the results are tabulated in Table VIII .

Figure 7 shows the effect of weight fraction of fused zirconia alumina particles on the impact strength. The results show a slow increase in impact strength with the addition of reinforcement particles upto 10% but tend to decrease at 15% addition of reinforcement particles.

Figure 6. An impact test specimen

Table VIII. Impact test results

Specimen	Composition	Impact strength (Nm)
A	Al6061 (100)	8
B	Al6061(95)+ FZA (5)	10
C	Al6061(90)+ FZA (10)	15
D	Al6061(85)+FZA(15)	13

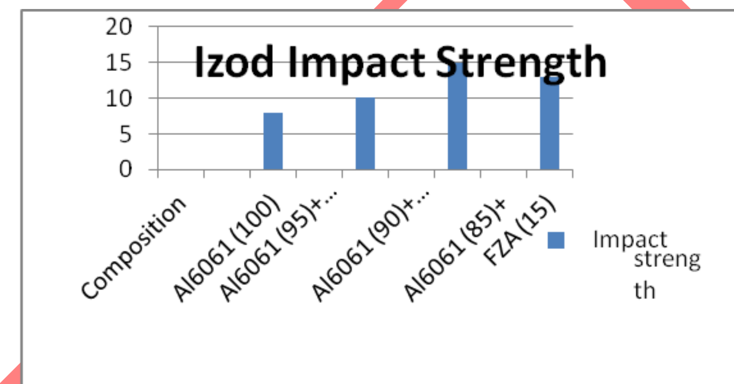

Figure 7. Impact test results

CONCLUSION

From the results it is clear that the best percentage of matrix and reinforcement is 90 and 10 respectively that gives more desirable properties.

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REFERENCES

[1] Daniel B. Miracle and Steven L. Donaldson, "Introduction to Composites", ASM Hand Book of Composite Materials, volume-21.

[2] U. C. Jindal, Material Science and Metallurgy, Pearson Education, ISBN:978-81-317-5911-0.

[3] Ibrahim, I. A., Mohamed, F. A., Lavernia, E. J., 1991, "Metal Matrix Composites" A Review Journal of Material Science, Vol.26, pp.1137 – 1157.

[4] Veeresh Kumar., Rao, C.S.P., Selvaraj, N., 2011, "Mechanical and Tribological Behavior of Particulate Reinforced Aluminum Metal Matrix Composites" – a review, Journal of Minerals & Materials Characterization & Engineering, Vol. 10, No.1, pp.59-91

[5] Rajan, T.P.D., Pillai, R.M., Pai, B.C., Satyanarayana, K.G., Rohatgi, P. K.,2007, "Fabrication and characterisation of Al– 7Si–0.35Mg/fly ash metal matrix composites processed by different stir casting routes", Composites. Sci. Technology 67: 3369-3377.

[6] Taha, A. Mohamed, Materials and Design, Vol. 22 (2001) pp 431- 441.