Evaluation of Mechanical Properties of Al 7075 – Zro_2 Metal Matrix Composite by using Stir Casting Technique

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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 work the Metal Matrix composites is developed by reinforcing of Zirconium oxide Nano powder in Aluminum alloy Al7075, using Stir Casting Technique. 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. To investigate the mechanical properties of (Tensile strength, Impact Test, and Hardness) Metal Matrix Composite's.

Keywords *–Al 7075, Metal Matrix Composites, Stir Casting Technique,* Zro_2

I. INTRODUCTION

The effects of research in Aluminum based Metal Matrix Composites (MMC's) are far reaching these days. These composites find various applications in the automobile industry, the aerospace industry and in defence and marine engineering because of their high strength-to-weight ratio, high stiffness, hardness, wear resistance, high temperature resistance etc., compared to others. In metal matrix composites, extensive research work has been carried out on Al alloys [1, 2]. The matrix is the monolithic material into which the reinforcement is embedded, and is completely continuous. This means that there is a path through the matrix to any point in the material, unlike two materials sandwiched together.

Aluminum Alloy 7075 offers the highest strength of the common screw machine alloys. The superior stress corrosion resistance of the T173 and T7351 tempers makes alloy 7075 a logical replacement for 2024, 2014 and 2017 in many of the most critical applications. The T6 and T651 tempers have fair machinability. Alloy 7075 is heavily utilized by the aircraft and ordnance industries because of its superior strength. [3]

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 [4]. The simple term composites‟ gives indication of the combinations of two or more material in order to improve the properties [4]. Matrix composites are made to lower the cost, reduced weight and high performance which can be easily available in the market for our use.

1.1 Selection of Materials:

For conducting of experiments we selected Aluminum 7075 as Matrix Material & Zirconium dioxide Nano powder (Zro_2) as Reinforced material.

1.1.1 Matrix Material:

Al 7075
It is strong, with strength comparable to many steels, and has good fatigue strength, average machinability, high thermal and electrical conductivity but has less resistance to corrosion than many other Al alloys. It is used in sporting goods, electronic packaging, armours and automotive industries.

Table: 1 Chemical Composition of Aluminum Al7075

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 Al 7075

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

1.1.2. Reinforced Material:

Zirconium Oxide Nano Powder (Zro_2)

Zirconium is a very strong, malleable, ductile, lustrous silver-gray metal. Its chemical and physical properties are similar to those of titanium. Zirconium is extremely resistant to heat and corrosion. Zirconium is lighter than steel and its hardness is similar to copper. Zirconium does not dissolve in acids and alkalis.

Table: 3 Properties of Zro_2

Density	g/cm^3	5.81
Bending Strength	MPa	600 – 1400
Compressive Strength	MPa	3500 – 5600
Vickers Hardness	HV	1250 – 1300
Melting Point	^{0}C	2700
Boiling Point	^{0}C	5500

2. Experimental Procedure:

In this experiment we consider Al 7075 with Zirconium Oxide Nano Powder (Zro_2) as weight 0%, 5%, & 10% respectively.

Composites are produced by using Stir Casting technique as shown in figure. Al 7075 is taken in the form of cylindrical rods for the experiments. Temperature about 600^0 - 750^0 is set in an electric furnace with control panel. The cylindrical rods are placed inside the graphite crucible.

The graphite crucible containing rods now placed inside the furnace and it is heated until reaches its melting point, once the metal reaches into the liquid state the slag formed on the surface will be removed slowly. The reinforced material Zirconium Oxide Nano powder (Zro_2) is preheated in the electric furnace at 800^0 temperature in order to remove the moisture in Zro_2 Nano Powder. Now add the Zro2 Nano Powder in the Aluminum 7075 liquid state slowly by stirring the graphite rod at speed of 400 rpm. Stirring is done very slowly for 5 to 10min because it will mix properly.

Now pour the liquid metal in the required die dimensions 100mm*100mm*10mm in order to conduct the experiment on mechanical properties.

Table: 4 weight % of Materials used in Experiment

S.No	% of Al 7075 by weight	% of Zro_2 by weight
1	100	-
2	95	5
3	90	10

Fig: 1 Electric Furnace

Fig: 2 Stir casting setup

Fig: 3 Pouring of Molten Metal in Die

2.1 Machining Process:

The Machining processes of Mould Components were machined with the help of EDM wire cutting machine as per the ASTM standard specification.

Fig: 4 EDM Machine

3. Experimental Details:

The Mechanical Properties are considered on Al7075 reinforced with 5%, 10% Zirconium Oxide Nano Powder (Zro_2).

3.1 Tensile Strength Test Specimen Details**:**

The machining is done by EDM wire cutting machine, the good surface finish and precise dimensions.

The cast specimens were machined to the dimensions as per the ASTM E8M04 Standards.

Fig: 5 Tensile Test Specimen

3.2 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 Al7075/FZA composite specimens prepared as per Standard test methods for Brinell hardness testing ASTM A370.

In the brinell test, a steel indenter, having dimension 1 inch square is forced in the surface of the composite. Standard load of 250 kg f is supplied and maintained constant for 10 seconds and then removed. Brinell hardness number is calculated from the impression of the indentation.

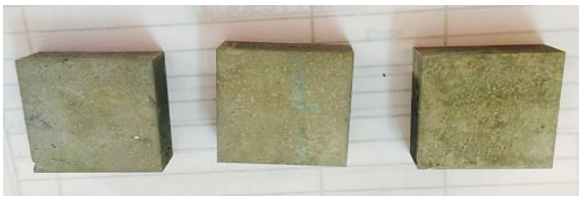

Fig: 6 Hardness Test Specimens

3.3 Charpy impact test specimen details:

Impact strength is the capacity of a material to withstand blows without fracture. The Charpy impact test is done on the Al7075/FZA composite specimens as in Fig. as per Standard test methods for V notched bar tensile strain Impact test method 'ASTM A370' in Impact testing machine.

Fig: 7 Impact Test Specimen

4. Results & Discussions:

4.1 Tensile Test:

Specimen	Composition	Ultimate Strength N/mm^2	Ultimate Load KN
A	100% Al7075	50.887	5.220
B	95% Al7075 + 5% Zro_2	135.05	13.50
C	90% Al7075 + 10% Zro_2	53.55	5.820

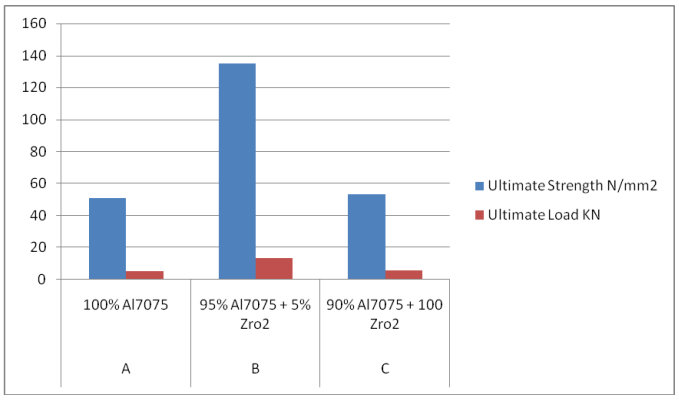

Fig: 8 Tensile Test Details

4.2 Hardness Test:

S.No	100% Al7075	95% Al7075 + 5% Zro_2	90% Al7075 + 10% Zro_2
1	96.1	97.2	103
2	97.2	98.3	104
3	97.2	97.2	104
Average	**96.83**	**97.57**	**103.67**

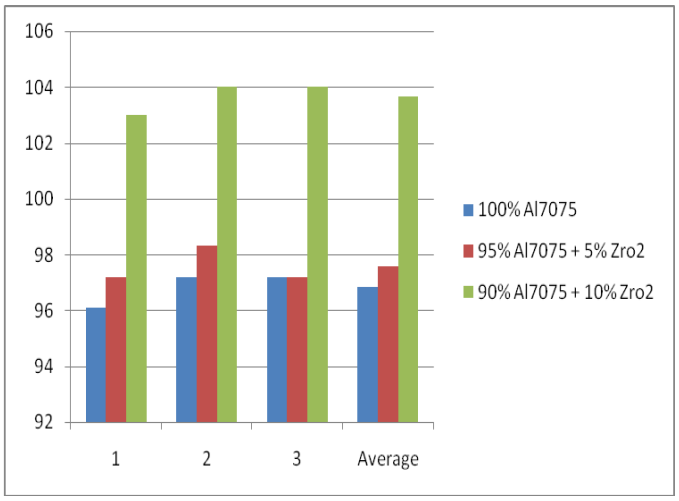

Fig: 9 Hardness Test Details

4.3 Impact Test:

S.No	Composition	Observed Values (Joules)
A	100% Al7075	**2**
B	95% Al7075 + 5% Zro_2	**2**
C	90% Al7075 + 100 Zro_2	**2**

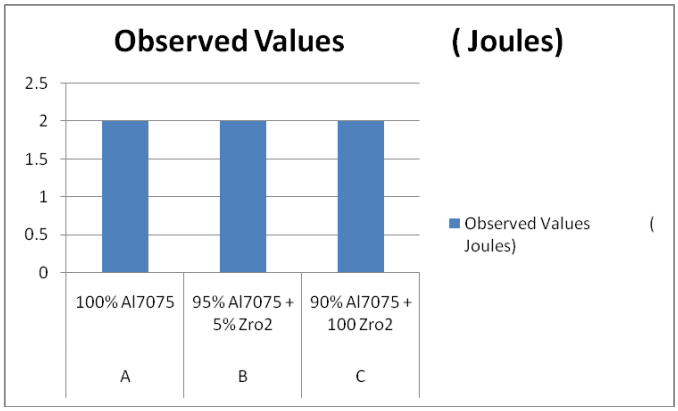

Fig: 10 Impact Test Details

5. Conclusion:

1) The tensile properties of composite were considerably improved by the addition of Zirconium Dioxide-particles.

2) The maximum tensile strength was observed at 95% Al 7075 + 5% Zro_2, is 135 N/mm^2

3) By adding of 10% zirconium Nano powder (Zro_2) with 90% Al 7075 the hardness properties are improved.

4) The maximum hardness was observed at 10% zirconium Nano powder (Zro_2) with 90% Al 7075 is 104.

References

1. M. Benachour, N. Benachour, and Benguediab, “Fatigue crack initiation of Al-Alloys-Effect of Heat treatment condition”, International Journal

of Mechanical, Aerospace and Mechatronics Engineering, Vol. 7, No. 11, pp. 1195-1197, 2013.

2. S. Bodhak, S. Bose and A. Bandyopadhyay, “Microwave Sintering of Mullite and Mullite Zirconia Composites” in Innovative Processing and Manufacturing of Advanced Ceramics and Composites, No. 212, pp. 95-103, 2010.

3. EzhilVannan and S. Paul Vizhian, “Microstructure and mechanical properties of as case aluminium alloy 7075/Basalt dispersed Metal Matrix Composites”, Journal of Minerals and Materials Characterization and EngineeringNo. 2, pp. 182-193, 2014

4. Rajesh kumar Gangaram Bhandare, “Preparation of Aluminium Matrix Composites by using Stir Casting Method” International Journal of Engineering and Advanced Technology, volume-3 issue -2 Dec 2013.

5. Sato and R. Mehrabian, “Aluminum matrix composite: fabrication and properties”, Metall. Trans. B, 7B, 443-51 (1976).

6. Sachin Malhotra, Ram Narayan, R. D Gupta, “Synthesis and Characterization of Aluminium 6061 Alloy-Fly ash& Zirconia Metal Matrix Composite”, International Journal of Current Engineering and Technology, Vol. 3, No. 5, pp. 1716-1719, 2013.

7. K. B. Girisha, Dr. H. C. Chittappa, “Preparation, Characterization and Wear Study of Aluminium Alloy (Al 356.1) Reinforced with Zirconium Nano Particles”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 8, pp. 3627-3637, 2013.