



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 1, January 2021

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.512

9940 572 462

6381 907 438

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Experimental Investigations on Al₂O₃ and Bottom Ash Reinforced with Aluminium Metal Matrix Composites for Structural Applications

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ABSTRACT: Al-7075 is extensively used in transport applications like marine, automotive and aerospace, because Al-7075 alloys have good cast ability, high corrosion resistance and low density [2]. The present work investigates the behaviour of aluminium metal matrix composite reinforced with Al₂O₃ and bottom ash to study mainly the strength aspects for structural applications. The addition of Al₂O₃ is varied from 2–6% percent by weight of aluminium matrix and keeping bottom ash constant in order to study the effect of bottom ash. Composite beams will be tested under flexural load conditions in order to evaluate their mechanical property such as load-deflection criteria. These results will be compared with those obtained from plain aluminium metal [8].

KEYWORDS: Aluminium 7075, Weight fraction, Mechanical properties and Stir casting process.

I. INTRODUCTION

Composite material is a material consists of two or more different phases (matrix phase and reinforcement phase) and having properties more significantly different from those of any of the constituents. Demand for developing metal matrix composites for use in high performance application have significantly increased in the recent years. The major advantages of aluminium matrix composites compared to unreinforced materials are, high hardness, high tensile strength and wear resistance. Because of these improved properties, MMC's are increasingly being utilized in high technology applications such as aerospace, defense and automobile [9] [10].

II. EXPERIMENTAL WORK

2.1 Material Selection

The aluminium alloy Al-7075 has been selected as the matrix material is more compatible with the reinforcement and has good mechanical property and castability at the alloy level itself. The application of the alloy in automobile and aircraft application itself indicated that it is the proper selection [1] [3].

Table1. Composition of Al7075 (Wt %)

Components	Cu	Cr	Mn	Mg	Si	Ti	Zn	Fe	Al
Components %	1.6	0.15	0.3	2.5	0.4	0.2	5.5	0.5	88.85



Table2. Properties of Aluminium Oxide

Property	Value
Melting Point °C	2072
Hardness (kg/m m2)	1175
Density(g/cm3)	3.69
Coefficient of thermal expansion (micron/m °C)	8.1
Fracture Toughness	3.5
Poisson's ratio	0.21
Colour	White

Table3. Composition of bottom ash (Wt %)

Components	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	MgO	CaO	K ₂ O	LOI
Components %	54.8	28.5	8.49	2.71	0.35	4.2	0.45	Rem.

2.2 Fabrication of Hybrid Composites

The composites used in this study were prepared by stir casting method [2]. Initially, aluminium 7075 ingots were placed in crucible. Molten metal was created using resistance furnace at a temperature of 800° C and the melt was degassed by adding degasser. Weight measurement of Al-7075 pieces is carried out and then bottom ash is taken as weight percentage of Al-7075. The Al₂O₃ is taken as varying percentage of 0%, 2%, 4% and 6% and keeping bottom ash constant. Initially, switching the heater supply, allow the metal to melt in the crucible, by setting the suitable temperature. After proper melting add the measured quantity of Al₂O₃ and bottom ash respectively [5]. Uniform mixing out is carried by stirrer; the speed of the stirrer is maintained constant by varying the o/p of the dimmer stat. Addition of the scum powder, De-gassing tablets is done in order to remove the slag formation & gas and other impurities etc. The crucible is taken out from the furnace and the molten metal is poured into the die cavity and allowed to solidify after solidification the required shape and size of the components was obtained.

The samples are prepared by the stir casting method are

Sample 1: Aluminium 7075 alloy 100%

Sample 2: Aluminium 7075 alloy 96% + Al₂O₃ 2% + Bottom ash 2%

Sample 3: Aluminium 7075 alloy 94% + Al₂O₃ 4% + Bottom ash 2%

Sample 4: Aluminium 7075 alloy 92% + Al₂O₃ 6% + Bottom ash 2%

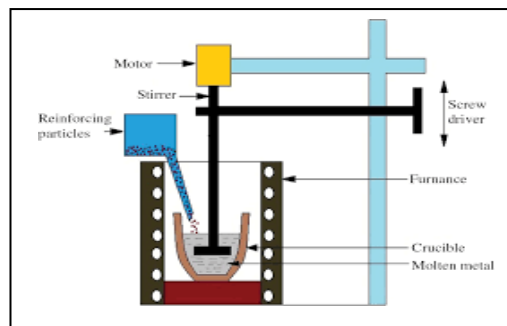


Fig.1 Stir Casting Method

III. RESULTS AND DISCUSSIONS



Fig.2 Tensile, Compression, Impact and Wear test specimens

3.1 Tensile Test

Tensile tests were conducted to determine mechanical properties of materials. The composite specimens are machined to tensile specimens with a diameter of 18mm and gauge length 71mm subjected to gradually increasing uniaxial tensile load until it fractures. It was observed that the tensile strength is increased in sample 2 specimen.

Table4. Tensile test results

Sample No.	Tensile Strength (MPa)	Yield Strength (MPa)	Elongation (%)	Breaking Load (KN)
Sample 1	140.5	125	1	17.35
Sample 2	166.86	133.315	0.46	19.7
Sample 3	76.19	61.26	2.28	9.39
Sample 4	159.13	126.01	1.18	21.48

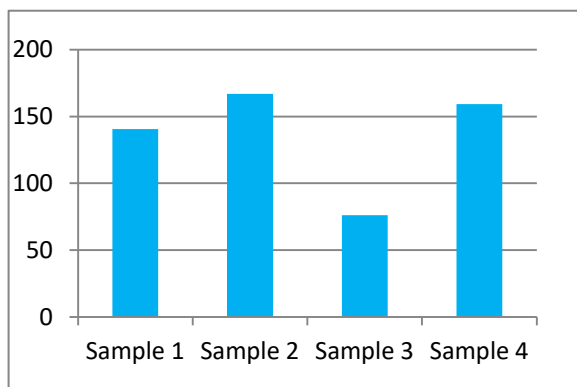


Fig. 3.1a Tensile strength (MPa)

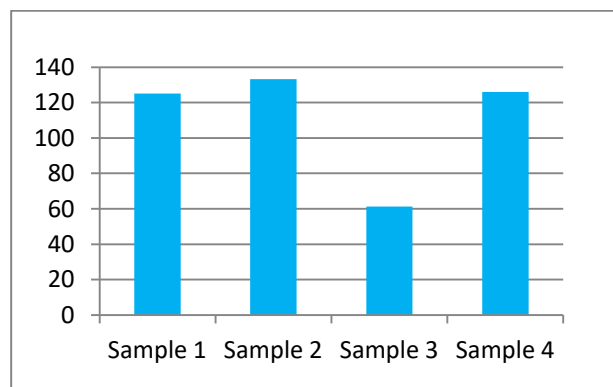


Fig. 3.1b Yield stress (MPa)

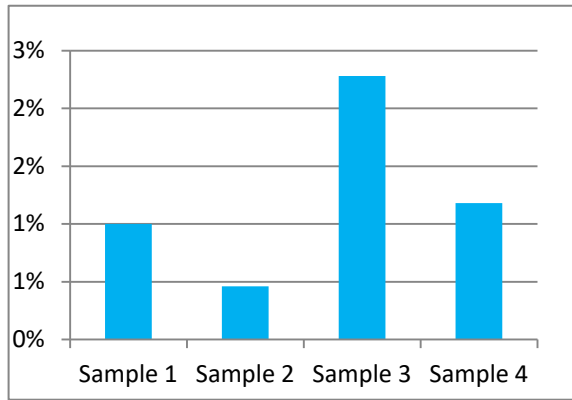


Fig. 3.1c Elongation (%)

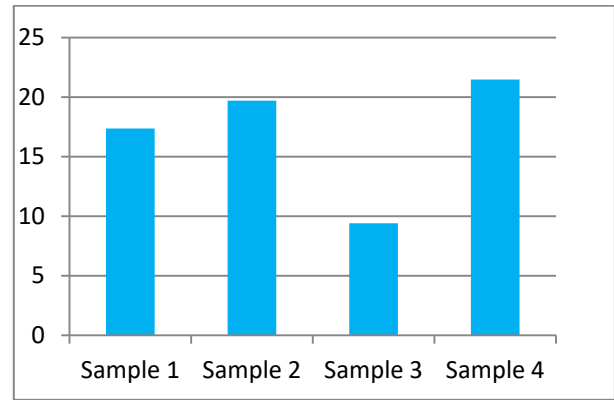


Fig. 3.1d Breaking load (KN)

3.2 Compressive Test

Compressive tests were conducted to determine mechanical properties of materials. The composite specimens are machined to compressive specimens with a diameter of 20mm and thickness 15mm subjected to gradually compressive load until it compress. It was observed that the compressive strength is increased in sample 2 specimen.

Table5. Compressive test results

Sample No.	Compression Strength (MPa)	Load at Peak (KN)	Elongation at Peak (mm)
Sample 1	588.85	186.10	8.22
Sample 2	594.80	187.98	8.55
Sample 3	350.60	112.90	6.05
Sample 4	570.96	180.99	9.54

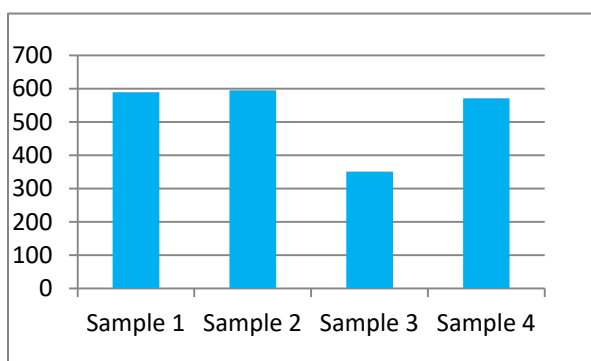


Fig. 3.2a Compression strength (MPa)

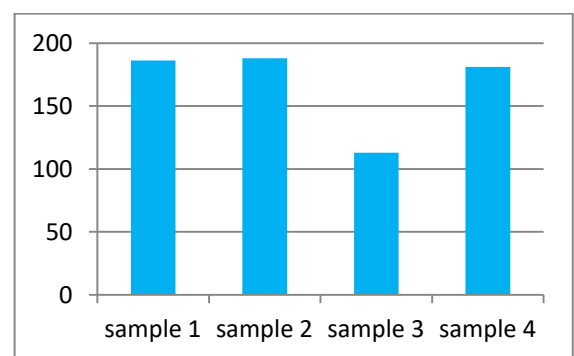


Fig. 3.2b Load at peak (KN)

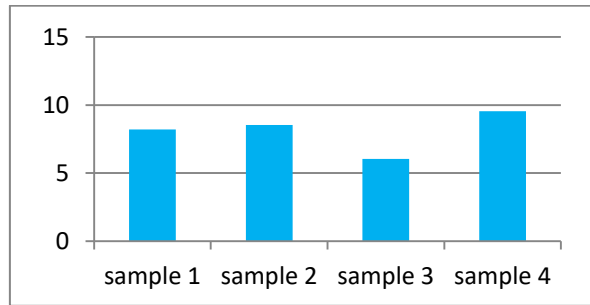


Fig. 3.2c Elongation at peak (mm)

3.3 Wear Test

The Wear was performed on a pin-on disc apparatus in order to study the tribological properties such as wear rate, coefficient of friction and porosity. It was observed that the wear strength is increased in sample 2 specimen

Table6. Wear test results

Sample No.	Average wear (micron)
Sample 1	139
Sample 2	167
Sample 3	57
Sample 4	47

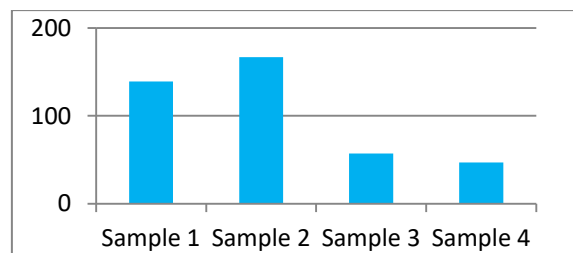


Fig. 3.3a Wear strength

3.4 Impact Test

Impact test were used to determine the amount of energy absorbed by material during fracture. It is called as Charpy impact test or Charpy V-notch test. The impact test specimens are in shown in figure 3.4a.

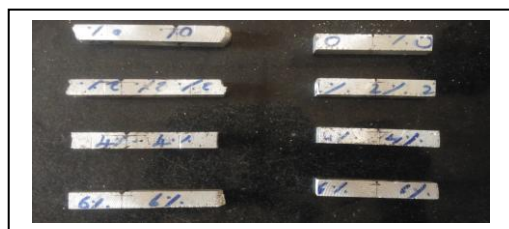


Fig. 3.4a Izod and Charpy impact test specimens



3.4.1 Izod Test

Table7. Izod test results

Sample No.	Energy Absorbed (Joule/mm ²)
Sample 1	0.045
Sample 2	0.050
Sample 3	0.054
Sample 4	0.058

3.4.2 Charpy Test

Table8. Charpy test results

Sample No.	Energy Absorbed (Joule/mm ²)
Sample 1	0.0425
Sample 2	0.0475
Sample 3	0.0500
Sample 4	0.0525

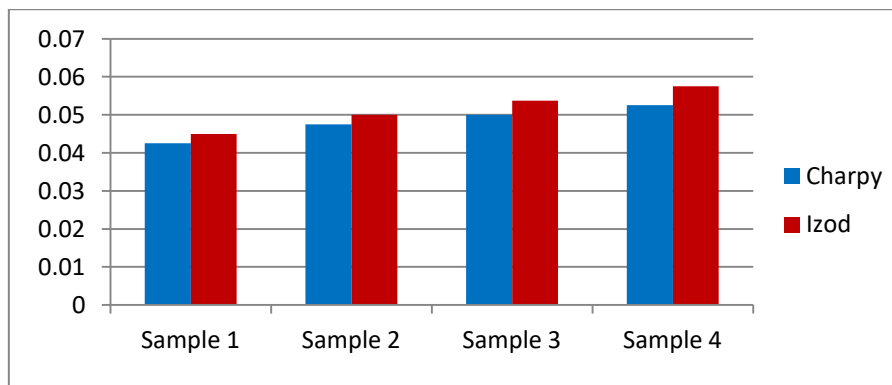


Fig. 3.4b Comparison of Izod and Charpy test results

IV. CONCLUSION

Al 7075/Al₂O₃/Bottom ash hybrid composites were successfully fabricated using stir casting process and conducted experiments on Universal Testing Machine, Izod, Charpy Test and Pin on Disc Wear Test Machine in order to evaluate mechanical properties such as Tensile strength, Compressive strength, Impact strength and Wear strength.

- [1] It reveals that at same percentage of Al₂O₃ and Bottom ash particles the tensile strength, yield strength and compressive strength of the composite were increased.
- [2] Further, increase in weight % of Al₂O₃ and bottom ash particles exceeds 2% , tensile and compressive strength decreases due to the clustering/agglomeration at high weight % of Al₂O₃ and bottom ash particles.
- [3] The impact strength of composite increases as wt% of Al₂O₃ increases due to Al₂O₃ is hard material.
- [4] At the same wt% of Al₂O₃ and bottom ash wear strength of composite increases due to distribution of hard or soft particles filled in the matrix.



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