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Testing and Analysis of Mechanical Properties of AL- ZRSIO4 C-Hybrid Nano Composites

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Abstract: The Aluminium based Metal Matrix nano composites (MMCs) have superior properties than the parent metal Al such as better performance, light weight, corrosion and wear resistance etc. These advantageous properties of MMCs attracts the industries to enhance their usage in automotive, armaments, astronautics and tribological applications. In the field of automobiles, MMCs are used for manufacture of pistons, connecting rods, brake drums and cylinder block etc. This research focus on the fabrication of the Al-ZrSiO4-C-hybrid nano composites using stir casting method, testing and analysing the properties of this hybrid nano composites using various tests as per ASTM standards, and then, identifying the superior strength of this hybrid nano composite. All the test results show that the mechanical strength of the Al-ZrSiO4-C hybrid nano composite is superior to a large extent than the base metal Aluminum. Hence, it can be used advantageously in engineering applications.
Keywords: Aluminium, Zirconium, Graphite, Tensile, Compression, Hardness.

I. INTRODUCTION

Aluminium based Metal Matrix Composites (MMCs) are having wider range of engineering applications because of its superior properties. They possess superior properties such as good strength, thermal conductivity, damping properties, lower density, low coefficient of thermal expansion, light weight, high performance, high specific stiffness, high specific strength, increased fatigue resistance, superior dimensional stability at elevated temperatures, high specific elasticity modulus, corrosion resistance, tough, nonmagnetic, durability, Improved abrasion and wear resistance etc [1-4]. These advantageous properties of MMCs attracts the industries to enhance their usage in automotive, armaments, astronautics and tribological applications.

In order to obtain a material with increased mechanical properties, reinforcement with superior properties has to be dispersed uniformly in to the base metal Aluminium in nano size. The reinforcement so selected should be thermodynamically stable, less susceptible to cracking because of lack of intermediate layers, well bound to the matrix etc. Micro structural studies indicates that the good and uniform bonding between the matrix and the dispersion material gives good strength [1,2].Mechanical properties of composite materials reinforced with ceramic particles depend on the matrix type, mutual wet ability, amount of the reinforcing phase, and size of the reinforcing particles. Hardness of these materials depends on the contents of ceramic particulates in the matrix and grows with its increase. It is essential to design properly the structures of composites, which necessitates the uniform distribution of particles in their base metal matrix to obtain their superior functional properties [5-7].

The reinforcement particulates ZRSIO4 and Graphite Powder possess good strength, fracture toughness, wear resistance and all good mechanical properties. Hence when these particulates are reinforced in to the Aluminium metal matrix in nano size, the resultant hybrid nano composites will have the superior properties of AMMC [8-10]. Hence, in this investigation, Al metal is chosen as the base metal and Zircon sand and Graphite powder are selected as the reinforcement materials. This hybrid nano composite is made through stir casting process and its various mechanical properties are analysed through various testing methods carried out as per ASTM standards and is presented in the following discussions.

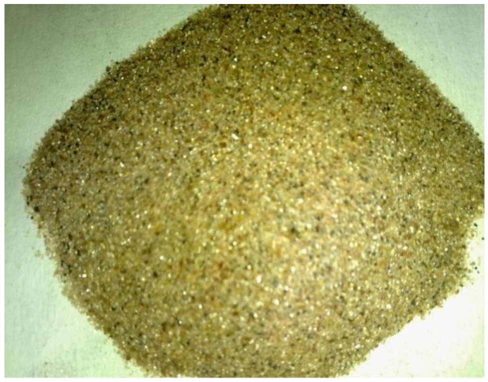
II. MATERIALS AND METHODS

British aluminium alloyHE9 rod of diameter 12.7mm is used as the base metal. The alloy contains Si 0.2-0.6%,Fe 0.35% ,Cu0.10%,Mn 0.10% ,Mg 0.45%-0.9%,Cr 0.10% ,Zn 0.10% ,Ti 0.10% ,Other elements 0.05%-0.15% and the remaining is Al. The table 1 shows the properties of the raw materials and the table 2 shows the composition of the reinforcement particles.

Properties of $ZrSiO_4$		Properties of Graphite (C)	
Properties	Values	*Properties*	*Values*
M.P. (^{0}C)	2500	Atomic Number	6
Limit of application (^{0}C)	1870	Molecular Weight (g/mol.)	12.011
Hardness (Mohr's Scale)	7.5	Apparent Density (g/cm^3)	2.25
Density (g/cm3)	4.5 - 4.70	Bulk Density (g/cm3)	3
Linear coefficient of expansion (µm/m^{0}C)	4.5	Melting Point (°C)	3600 °C
Fracture toughness(MPa)	5	Boiling Point (°C)	4200 °C
Crystal structure	Tetragonal	Surface Area (m^3/g)	7.2

Table: 1: Properties of Materials used in the Hybrid Nano Composites.

(a).British Al alloy HE9



(b).Zircon Sand (ZRSIO4)

(c) Graphite Powder

(d) Fabricated specimen

Figure:1(a-c) Materials used and 1 (d).Fabricated Specimen

Composition of Al-ZrSiO4-C %	Al gm	(ZrSiO4) gm	(C) gm
90,5,5	1.8	0.100	0.100
80,10,10	1.84	0.080	0.080
82,4,4	1.6	0.200	0.200
90,7,3	1.8	0.140	0.060
90,3,7	1.8	0.060	0.140

Table 2: Composition of Materials used in the Hybrid Nano Composites

III. RESULTS AND DISCUSSION

IMPACT TEST

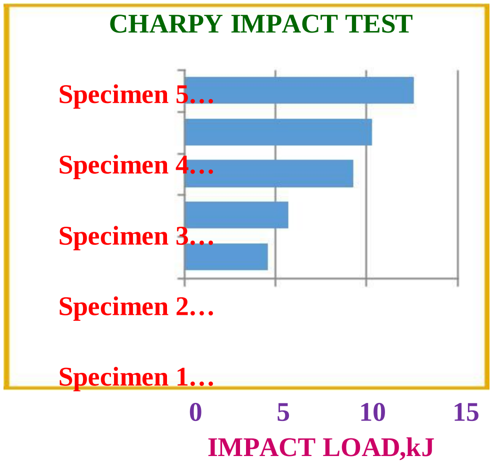


Figure - 2(a): Charpy Test Plot

Figure 2 (b). Specimen after the Impact Test

Composite	Impact Strength (Kj)
Specimen1 (2%+2%)	4.6
Specimen2 (4%+4%)	5.7
Specimen3 (6%+6%)	9.3
Specimen4 (8%+8%)	10.3
Specimen 5 (10%+10%)	12.6

Table - 3Results of Impact Strength

According to ASTM A370, the standard specimen size for Charpy impact testing used for this test is 10 [1] × 10mm × 55mm.The Impact Test on these test specimens indicates that the impact strength of the hybrid composite increases as 4.6 kJ,5.7 kJ,9.3 kJ,10.3 kJ,12.6kJ with the increase in contents of the reinforcements from 0 to 2, 4, 6, 8&10% as shown in table 3 and in the figure 2(a).The figure 2(b) also shows the worn out fashion of the specimen on the applied loads. This test result proves that the reinforcement particles improves the impact strength of the basic aluminium alloy material.

COMPRESSION TEST

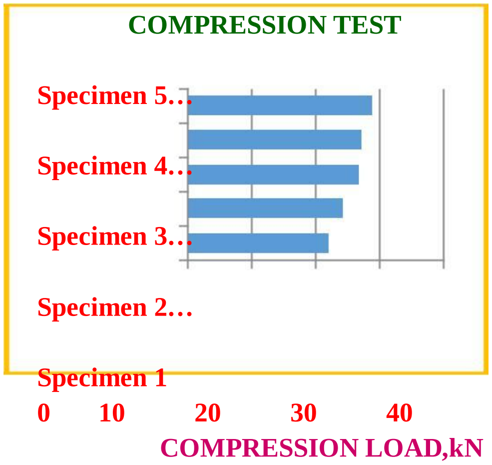


Figure: 3(a) :Compression Test Plot

Figure 3(b): Specimen after the Test

The Compression Test carried out on the specimen shows that when the reinforcement contents increasesfrom0 to 2, 4, 6, 8&10%, the compressive strength of the hybrid composite increases from the very low value of 22.1 kN to 29.0 kN as shown in Table and figure 3 (a&b).The figure also shows the worn out fashion of the specimen on the applied loads. This test result proves that the reinforcement particles improves the compressive strength of the basic aluminium alloy material.

HARDNESS TEST

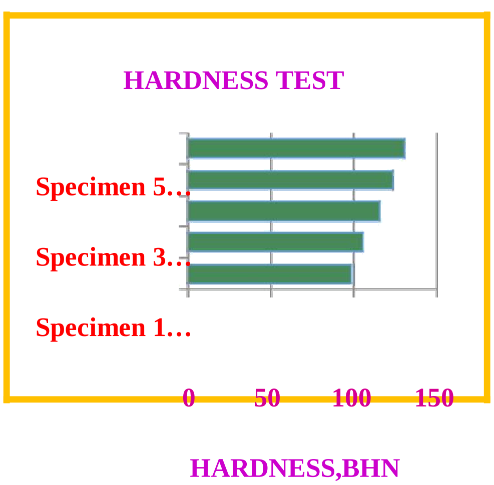


Figure 4: Hardness Plot

The Hardness test on these test specimen shows that the hardness of the composite increases from the minimum value of 98 BHN to 130BHN with the increase of the reinforcement contents in the composite from 0 to 2, 4, 6, 8&10% as shown in figure 4.It implies that the hardness of the composite increases with the increase in contents of the reinforcements from 0 to 2, 4, 6, 8&10%.This test result proves that the reinforcement particles improves the overall hardness of the basic aluminium alloy material.

IV. CONCLUSIONS

Thus all the test results as shown from table 8, show that the strength of this hybrid composite is superior than its parent metal Aluminium which withstand high impact(12.6kJ), compressive(29kN), tensile(13000N) and shear loads(24.98kN).With the of reinforcement contents, its strength further increases. Hence this hybrid nano composite can be advantageously used in engineering applications where the light weight and higher strength is required. In fields of aerospace, automobiles, shipping especially, this composite can be advantageously used.

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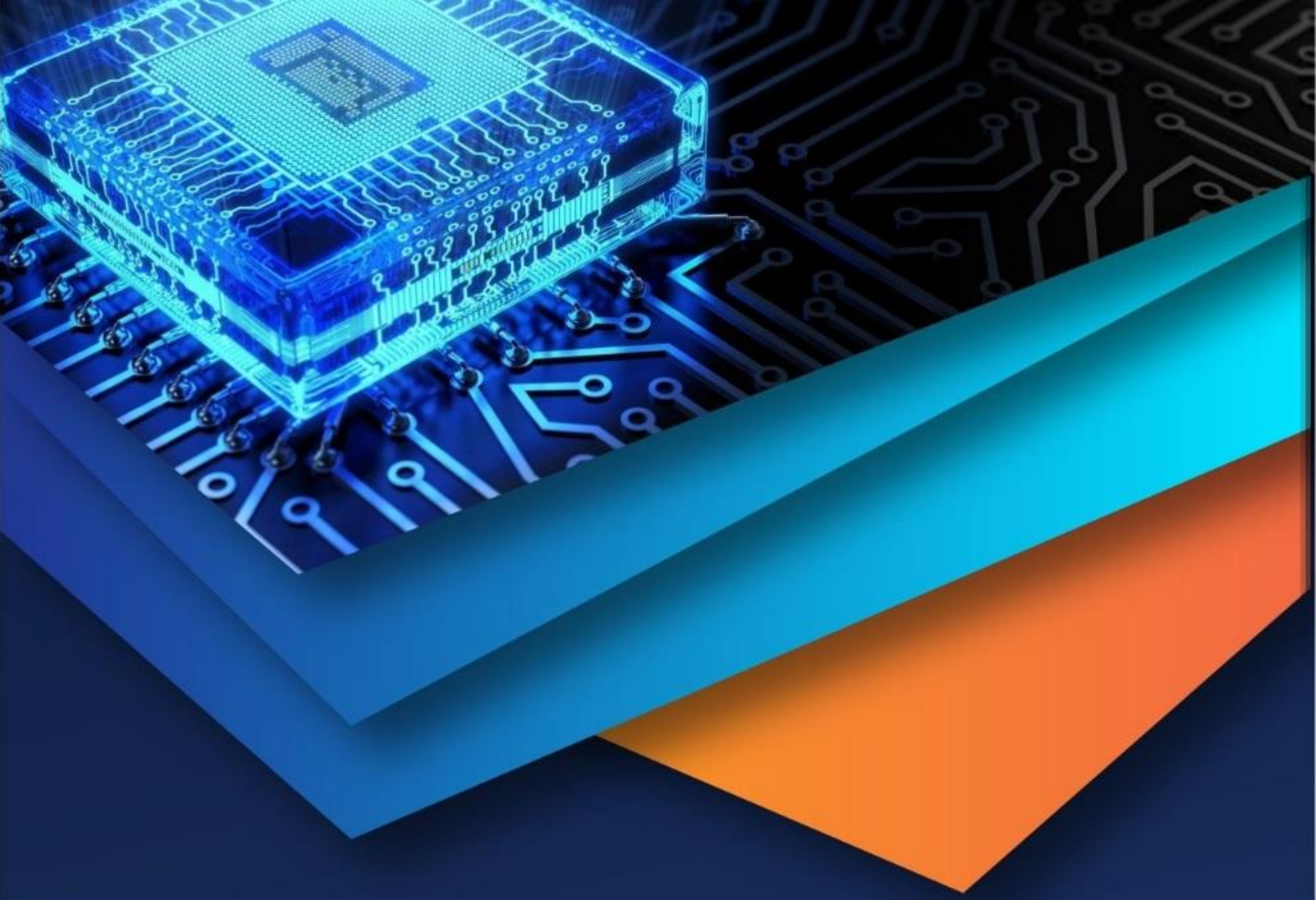

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