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MECHANICAL AND WEAR BEHAVIOR OF ALUMINIUM-ZIRCON SAND-FLYASH METAL MATRIX COMPOSITE

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Abstract. All Metal Matrix Composites are new materials which is a combination of molten metal called matrix and strengthening particles called reinforcement. This paper reveals the reinforcement of Zircon sand and fly ash with Aluminium alloy (LM6) with a specific ratio using stir casting technique to fabricate MMC. Here, Mechanical property namely tensile strength, hardness and Flexural strength are evaluated along with the Wear Analysis in Pin-on-Disc Apparatus under Abrasive Wear condition. The result shows that sample 4 has highest tensile strength of 170 MPa with hardness value of 57 HB. Also, the sample exhibited more wear resistance than other samples.

1.0 Introduction

Singla et al [1] found that ethanol solution at 50^0C is added while preheating the ash for the surface treatment, the addition of Mg increases the wettability which decreases the surface tension of the fly-ash. To remove the slag from the molten metal, hexachloro- Ethane tablets were added. Mohana Rao et al. [2] stated that by blowing the Argon gas at 2cc/min can minimize the high temperature oxidation problems. Also, to achieve sufficient turbulence and prevent deposition of Fly ash clusters on the crucible wall, the slurry was added at the rate of 4 mm/sec. Babu et al [3] studied that by preheating the Fly ash at 800^0C for two hours, it changes its colour from dark grey to brownish due to unburnt carbons deposition, which consists largely Silica (SiO_2), Alumina (Al_2O_3), Mullite ($3Al_2O_3.2SiO_2$) and small amount of hematite (Fe_2O_3). Okafor et al [4] studied that by increasing $ZrSi_4$ content in Aluminium during squeezing casting make the casting lesser porous and also improves the wettability and interfacial bond. By adding Zircon sand in the matrix alloy results in with elastic and plastic incompatibility due to difference in the co efficient of thermal expansion. They also observed that by adding 5-25% of Zircon sand in matrix material hardness value increases. Sunil Sharma et al [5] experimented by adding ZrO_2 in Al 6061 matrix, the percentage elongation will be reduced because of its brittleness. Kaur et al [6] stated that the reinforced composites will show less wear than the unreinforced alloy. Suchitharan et al [7] investigated the wear behavior of Al6063 and Zircon sand which was tested by pin on disc method. They found that by increasing Zircon sand percentage the wear rate was reduced and 8wt% $ZrSiO_4$ showed a high wear resistance. Sanjeev Kumar Yadav et al [8] stated that Zircon sand provides micro hardness and good internal bonding strength. By adding 50% TiC and 50% Zircon sand in ADC-12 alloy, better compressive strength was observed than the other combinations. Radhika et al [9] stated that the incorporation of graphite as primary reinforcement forms a protective layer between the pin and the counter face such that an increase in the wear resistance was observed. By adding alumina as a secondary reinforcement the significant changes in wear behavior of composite was observed. Singla et al [10] found that the sample which had 25% SiC content found to have higher hardness and toughness of 45.5 BHN and 36 N-m respectively. Beyond this weight fraction, the hardness will got decreased because of the interaction of SiC particles resulted in cluster formation. Vijaya Ramnath et al [11,12,14] investigated mechanical behavior of Aluminium metal matrix composites with Alumina-Boron Carbide, SiC and Boron Carbide as reinforcement. They found that addition of reinforcement increases mechanical properties of composites up to certain level beyond that the strength decreases. Elanchezhian et al [13,15] studied the compression and chemical Properties of Aluminium Nano Composites. It is also found that the wear volume loss and coefficient of friction were influenced by % Volume of Reinforcement addition [16]. Other than graphite, SiC reinforced composite showed more positive results on wear resistance when compared with fly ash reinforcements [17]. But in the case of impact properties comparative study between fly ash and S-Glass, a monotonically increase of impact strength were obsrved when fly-ash was reinforced in Aluminium matrix [18]. At dynamic and quasi-static states of Aluminium composite with Nano metricsized B_4C, strain softening and elastic near plastic behaviour was noticed [19].Being a light weight material, Aluminium finds most of its application in automotive industries especially the SiC reinforced Aluminium due to SiC's high ceramic hardness, high modulus of about 410 GPa and low CTE of 1 ppm/C [20]. Since, no work has been carried out using Zircon sand-fly ash as reinforcement with Aluminium, this paper aimed to fabricate metal matrix composites using Zircon sand-Fly ash with Aluminium.

2.0 Materials

Aluminium alloy (LM6):

This alloy has excellent corrosion resistance which is suitable for marine applications. This can be strengthened further by anodic treatment; however this changes the color from grey to a dark brown. Density of this material is 2.65g/cc.

Zircon sand and Fly ash:

Zircon sand is a naturally available material, which melts at 2100-2300^{0}C and has hardness of 7.0-7.5 Mohs.

3.0 Fabrication of composite

Raw Aluminium LM6 ingots are taken in the required amount in graphite crucible was placed for 2 hours inside the furnace maintained around 850-900^{0}c. At the same time, the Zircon sand and fly ash are preheated. When the Aluminium ingots melt completely, the Degasser was added to the molten metal which removed all the gasses and impurities presents in the molten metal. Then the cover all powder is added, which forms a layer on top of the molten metal since it retains heat inside the crucible. The preheated Zircon sand and fly ash were added 1% and 2.5% weight in the molten metal as shown in Table 1. The stirring process was carried out for 10 minutes and the stirring temperature was maintained around 650-700^{0}C. To avoid casting defects the die was be preheated to 500^{0}C, at which the molten metal poured in to the die (100x100x10mm) and later it was allowed to solidify. Table 1 shows composition of MMC fabricated in this work.

Table 1- Material Composition

Name of sample	Percentage of Aluminium alloy(LM6)	Percentage of Zircon	Percentage of fly ash
SAMPLE 1	100	-	-
SAMPLE 2	98	1	1
SAMPLE 3	95	2.5	2.5
SAMPLE 4	90	5	5

4.0 Testing of material

4.1 Tensile test: The composite sample was prepared as per ASTM: D638. This test was carried out in Universal Testing Machine, and done in normal atmospheric conditions (35^0C) in controlled relative humidity.

4.2 Hardness test: The hardness test was carried on Brinell Hardness Testing Machine, Avery make 3000 kgf with ASTM E10 standard.

4.3 Flexural Test: The Flexural (Compression) test was performed using the Universal Testing Machine [UTN 40 Model]. The test specimen was prepared as per ASTM E8 standard.

4.4 Wear Test: The Abrasion Wear test was conducted on Pin-on-Disc apparatus. The size of the specimen that was subjected to wear was 10mm diameter and 30 mm length as per ASTM G 99 standard. 60 Grade SiC abrasive sheet was used as Counter-Disc material. The rotational frequency was set to 24±1 rpm and the equivalent revolution is 84 times the normal revolution, and the load applied was 10N.

5.0 Results and discussions

5.1 Tensile Properties

The result of tensile test is shown in figure 1, from which it was observed that the sample-2 has higher strength than the other two compositions. This was due to the presence of Zircon sand and the ash in minimum percentage as compared to the other samples. Also, it is concluded that increase in reinforcement increases brittleness of materials which in turn reduces tensile behaviour.

Figure1. Result of Tensile test

5.2 Hardness

Figure 2 shows the result of hardness test, from which it is found that sample 2 which has 1% of Zircon and Fly ash has more hardness than the other 2 samples. This was due to the presence of reinforcement with minimum percentage

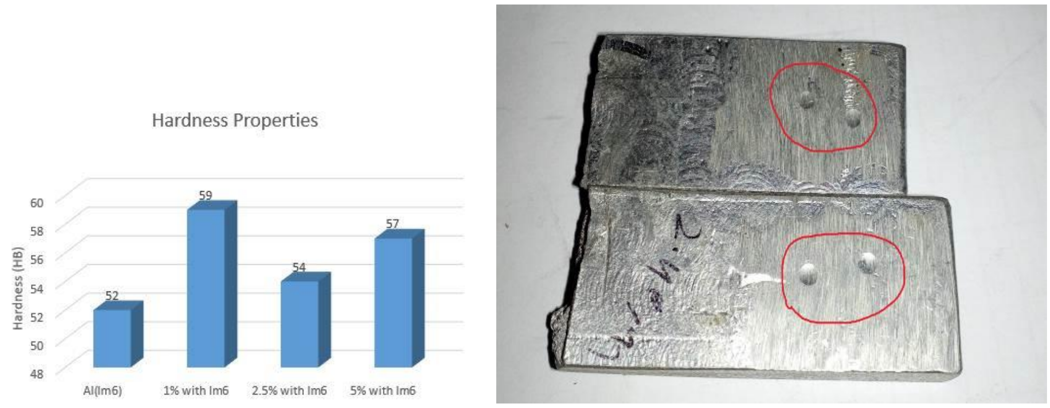

Figure2. Result of Hardness test

5.3 Flexural Properties

Figure3 shows the result of flexural test, from which was identified that, the sample which contained 2.5% of Zircon and fly ash had better flexural strength than the other samples. This was due to the presence of Zircon sand and fly ash, which withstood more bending load on the composite as compared to the other samples.

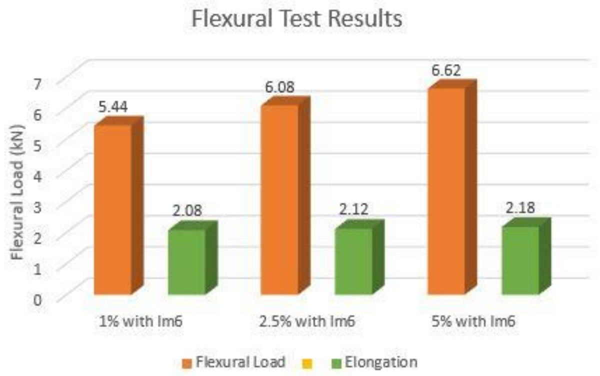

Figure3. Result of Flexural test

5.4 Wear Properties

The result of the wear test is given in Table 2. From the two samples, sample 4 had high wear resistance than the other samples due to the presence of high amount of reinforcement. The tested samples are shown in Fig 4.

Table2. Result of wear test

Sample No	Initial Weight (g)	Final Weight (g)	Abrasion Loss (g)	Loss (%)
2	5.4316	5.3077	0.1239	2.28
3	5.1068	4.9308	0.1760	3.45
4	5.1467	5.0394	0.1073	2.13

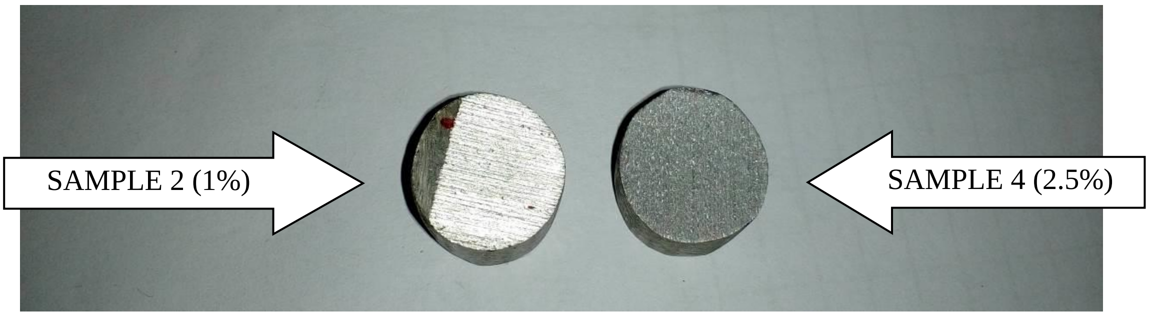

Figure 4. Wear test samples

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5.5 Morphological Analysis

This analysis was carried out to find the internal surface defect in the composite fabricated like blow holes, crack propagation and accumulation of reinforcement. Figure 5 shows fly ash accumulation which was due to improper stirring of reinforcements. Crack initiation was observed the sample as shown in figure 6. Also the accumulation of Zircon sand is shown in figure 7.

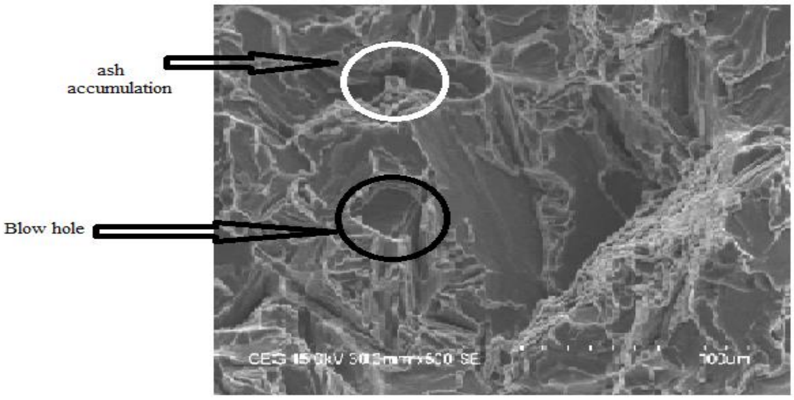

Fig.5 Accumulation of Fly ash

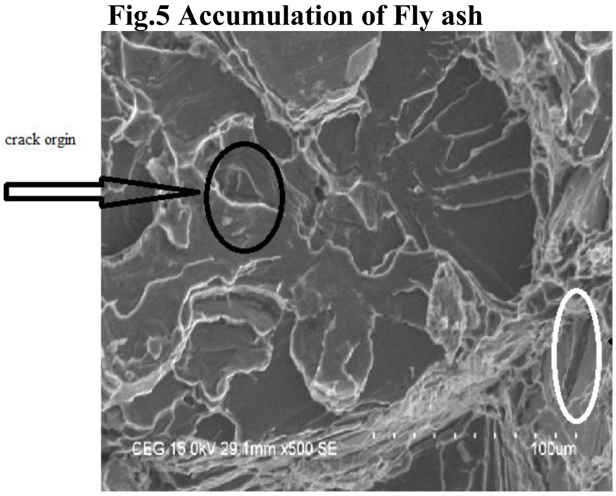

Fig.6 Crack Formation

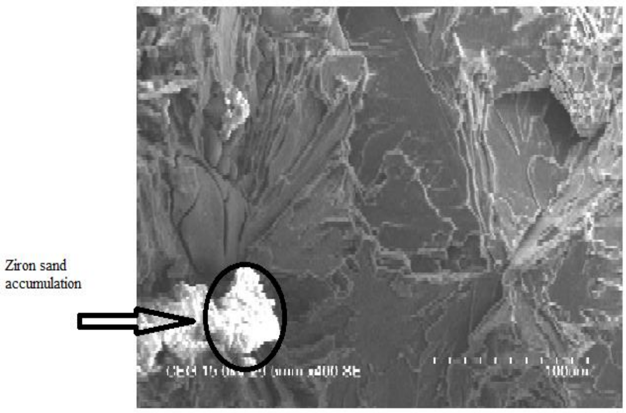

Fig.7 Accumulation of Zircon

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6.0 Conclusion

In this work the tensile, flexural and hardness of Al metal matrix composites reinforced with Zircon sand and Fly ash was investigated**.**

- It was found that samples which contain 1% of Zircon sand and fly ash has more tensile and hardness strength.
- In Flexural (bending) strength the sample which contains the 1% is less than the 2.5% of Zircon sand and fly ash.
- In Wear Resistant test the sample which contains 1% Zircon sand and fly ash has higher resistance than the other samples
- In figure 5-7 (Morphological Analysis) the accumulation of Fly ash and crack origin was reported

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