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Corrosion resistance of Al6061-basalt natural filler and zircon hybrid composite material in acid media

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ABSTRACT

The present investigation is an attempt made to develop Al6061/Basalt/Zirconium oxide Hybrid Metal Matrix Composites (MMCs) by liquid metallurgy technique (stir casting) and to study the wear properties of Al6061/Basalt/Zirconium oxide reinforced hybrid metal matrix composites. The composite is prepared by using Liquid Metallurgy Route (Stir Casting Technique), although other processing technique such as powder metallurgy delivers better mechanical properties in MMCs, Liquid state has some significant focal points, for example, better matrix molecule holding, simpler control of matrix structure, ease of handling, closer to net shape and wide choice of material. Al6061 is taken as a base material (matrix) and Basalt (1–10%) and Zirconium oxides (2%) are used as reinforcements. Corrosion analysis for Aluminum Metal Matrix Composites (MMCs) was done in acid (HCl) media at room temperature & different time intervals. The results were tabulated & it was found that the MMC containing 4% basalt underwent maximum corrosion at room temperature. SEM is done for all the samples the results are tabulated.

Selection and peer-review under responsibility of the scientific committee of the Emerging Trends in Materials Science, Technology and Engineering.

1. Introduction

Ordinary materials, like metals and their composites, ceramic, polymer materials can't meet the properties, like incorporated of strength, stiffness, density, durability and better corrosion resistance properties, which are essential for many of the modern industrial applications. Thus, these major limitations of the conventional metals paved the way for new class of metals known as COMPOSITE MATERIALS [1–4].

"The word composite in the term composite material signifies that two or more dissimilar materials are combined on a macroscopic scale to form a useful third material" [1–3]. Thus on a broad sense composites can be defined as "A combination of two or more materials, differing in form or composition on a macroscopic scale". However the material retains their identities, i.e. they do not mixing or combining completely in to one another, although they act as a single Material.

Thus from the definition of composites it is clear that composites are made up of individual material referred to as constituent materials. Out of these constituent materials one is continuous phase and is called as Matrix, while the subsequent one being discontinuous phase and it is named as reinforcement.

The continuous phase surrounds and supports the reinforcement material by maintaining their relative position. The reinforcement is chosen dependent on their characteristic properties like corrosion, oxidation, firmness and different properties, while matrix acts as a bonding element.

Aluminum and its combinations are the most broadly used as a matrix metal in view of their accessibility, light weight, simplicity of manufacture and genuinely high mechanical properties. Likewise audit of the past researchers demonstrates that lately, among all the Aluminum alloy compounds, Al6061 is increasing a lot of prevalence as a matrix material to fabricate MMCs inferable from its brilliant mechanical properties and great Corrosion opposition. Furthermore, Al6061 compound is additionally heat treatable and can be framed by auxiliary process, accordingly, further upgrades in quality and different properties can be expected. One of the reinforcement chosen in this work is Basalt. Basalt a name derived from the Latin for 'very hard stone', basalt is indeed a very hard, black igneous rock found all over Earth. It most commonly forms as an extrusive rock, such as a lava flow, but can also form in small

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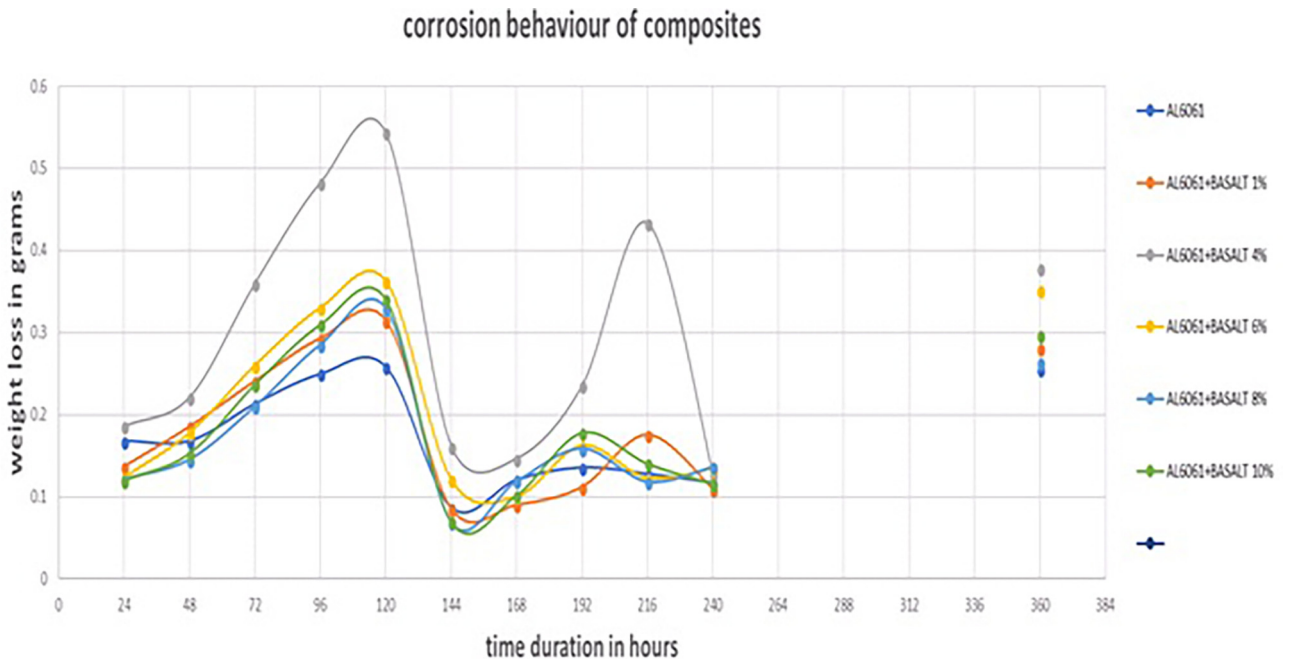

Fig. 1. Shows the corrosion behaviour in different percentage of Basalt in composite.

Table 1
Tabulated test results for Al6061 + 0% Basalt + 0% ZrO2.

Time duration in hours	Initial weight in 'g'	Final weight in 'g'	Difference weight in 'g'
24	3.3979	3.2609	0.137
48	3.2609	3.0754	0.1855
120	3.0754	2.7605	0.3149
144	2.7605	2.6753	0.0852
168	2.6753	2.5854	0.0899
192	2.5854	2.4464	0.112
216	2.4464	2.2707	0.1757
240	2.2707	2.1615	0.1092

Table 2
Tabulated test results for Al6061 + 2%Basalt + 2% ZrO2.

Time duration in hours	Initial weight in 'g'	Final weight in 'g'	Difference weight in 'g'
24	3.4975	3.3294	0.1681
48	3.3294	3.1614	0.168
120	3.1614	2.9026	0.2588
144	2.9026	2.8162	0.0864
168	2.8162	2.6956	0.1206
192	2.6956	2.5600	0.1356
216	2.5600	2.4324	0.1276
240	2.4324	2.3154	0.117

intrusive bodies, such as an igneous layers or a thin sill. It has property like thermal resistance, and wear resistance [5–8].

2. Experimental

Gravity weight reduction corrosion test according to ASTM standards is continued in our work. The examples of the projected Hybrid Metal Matrix Composites are made and cut into 8 × 25 mm size cylindrical shaped samples by standard metallographic procedures. The specimens are finely ground with silicon carbide paper

Table 3
Tabulated test results for Al6061 + 4% Basalt + 2% ZrO2.

Time duration in hours	Initial weight in 'g'	Final weight in 'g'	Difference weight in 'g'
24	3.4218	3.2362	0.1856
48	3.2362	3.0152	0.221
120	3.0152	2.4717	0.5435
144	2.4717	2.3104	0.1613
168	2.3104	2.1640	0.1464
192	2.1640	1.9287	0.2353
216	1.9287	1.7495	0.4337
240	1.7495	1.6225	0.127

Table 4
Tabulated test results for Al6061 + 6% Basalt + 2% ZrO2.

Time duration in hours	Initial weight in 'g'	Final weight in 'g'	Difference weight in 'g'
24	3.3001	3.1766	0.1235
48	3.1766	2.9987	0.1779
120	2.9987	2.6362	0.3625
144	2.6362	2.5153	0.1209
168	2.5153	2.4149	0.1004
192	2.4149	2.2525	0.1624
216	2.2525	2.1299	0.1226
240	2.1299	1.9952	0.1347

Table 5
Tabulated test results for Al6061 + 8% Basalt + 2%ZrO2.

Time duration in hours	Initial weight in 'g'	Final weight in 'g'	Difference weight in 'g'
24	3.3003	3.1789	0.1214
48	3.1789	3.0336	0.1453
120	3.0336	2.7046	0.329
144	2.7046	2.6363	0.0683
168	2.6363	2.5172	0.1191
192	2.5172	2.3587	0.1585
216	2.3587	2.2407	0.118
240	2.2407	2.1043	0.1364

Table 6
Tabulated test results for Al6061 + 10% Basalt + 2%ZrO2.

Time duration in hours	Initial weight in 'g'	Final weight in 'g'	Difference weight in 'g'
24	3.4601	3.3401	0.12
48	3.3401	3.1870	0.1531
120	3.1870	2.8463	0.3407
144	2.8463	2.7769	0.0694
168	2.7769	2.6748	0.1021
192	2.6748	2.4966	0.1782
216	2.4966	2.3561	0.1405
240	2.3561	2.2402	0.1159

1000 coarseness and washed with water and (CH3)2CO, dried and weighed utilizing electronic balance up to third decimal.

Weight reduction corrosion studies are tested for the samples prepared as referred above in the 1 M Hydrochloric acid solution (1 M HCl) at room temperature utilizing customary weight reduction method as indicated by ASTM 69–80. The tests are conducted as long as 96 h in steps of 24 h. Six quantities of 250 cm^3 glass beaker are taken and known amount of 1 M HCl is added to the beaker. The samples are weighed, dipped in 1 M HCl and taken out after 24 h.

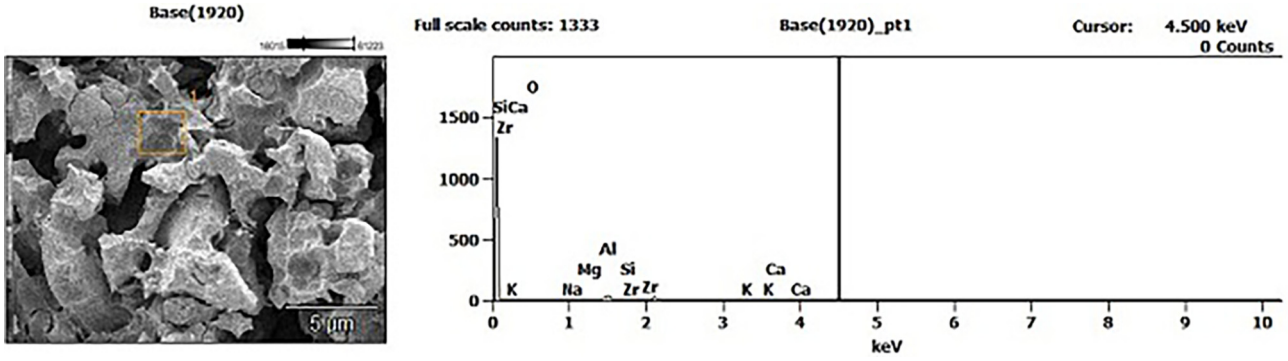

Fig. 2. The SEM results for Al6061 + 0% Basalt + 0% ZrO_2.

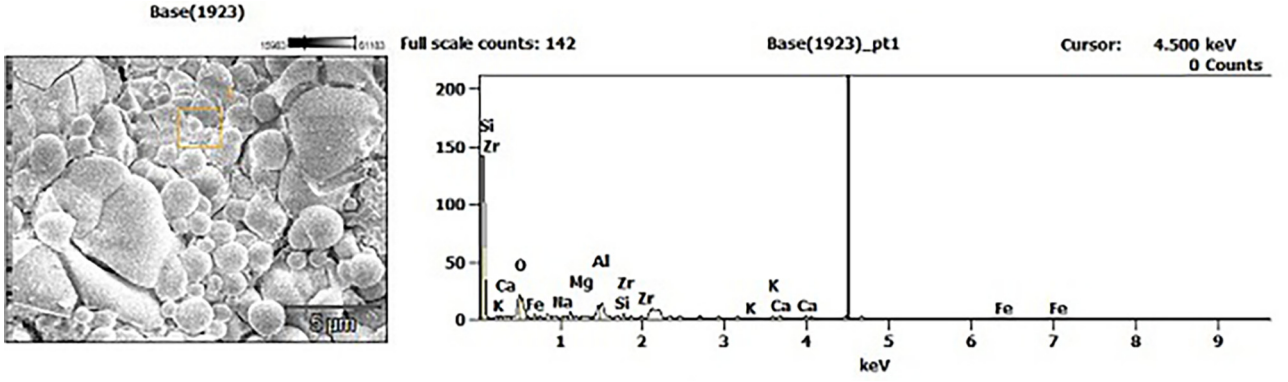

Fig. 3. The SEM results for Al6061 + 1% Basalt + 2% ZrO_2.

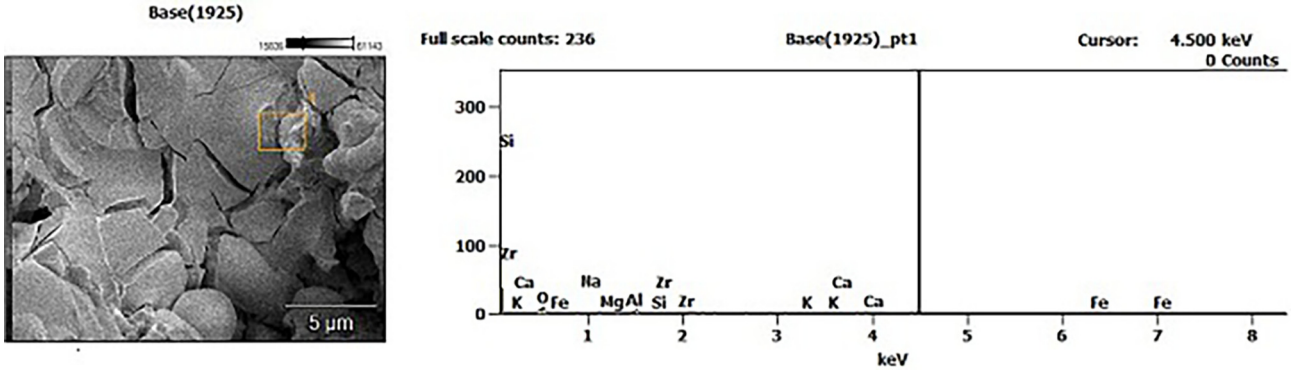

Fig. 4. The SEM results for Al6061 + 4% Basalt + 2% ZrO_2.

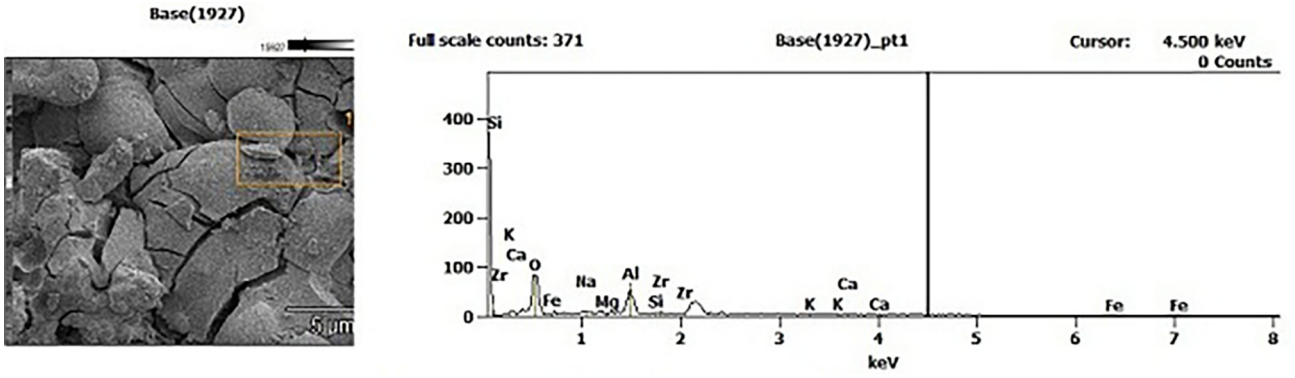

Fig. 5. The SEM results for Al6061 + 6% Basalt + 2% ZrO_2.

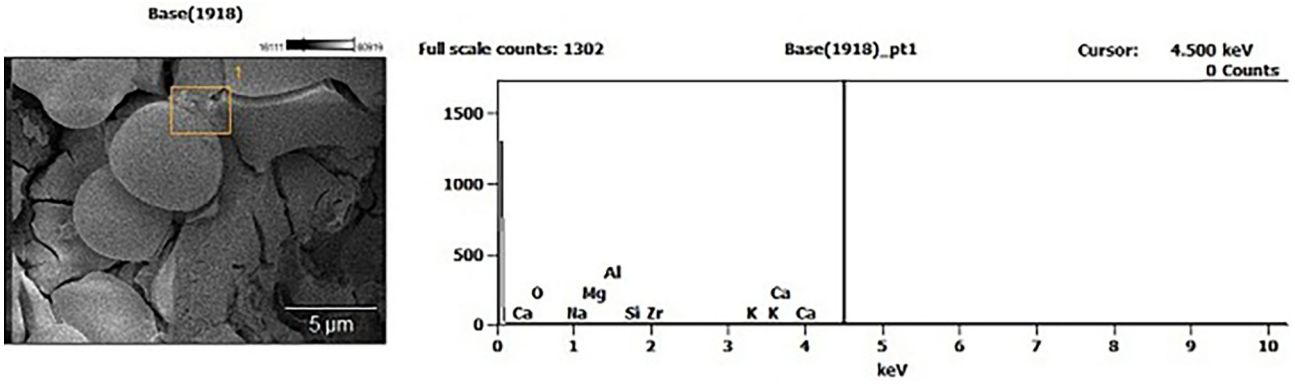

Fig. 6. The SEM results for Al6061 + 8% Basalt + 2% ZrO_2.

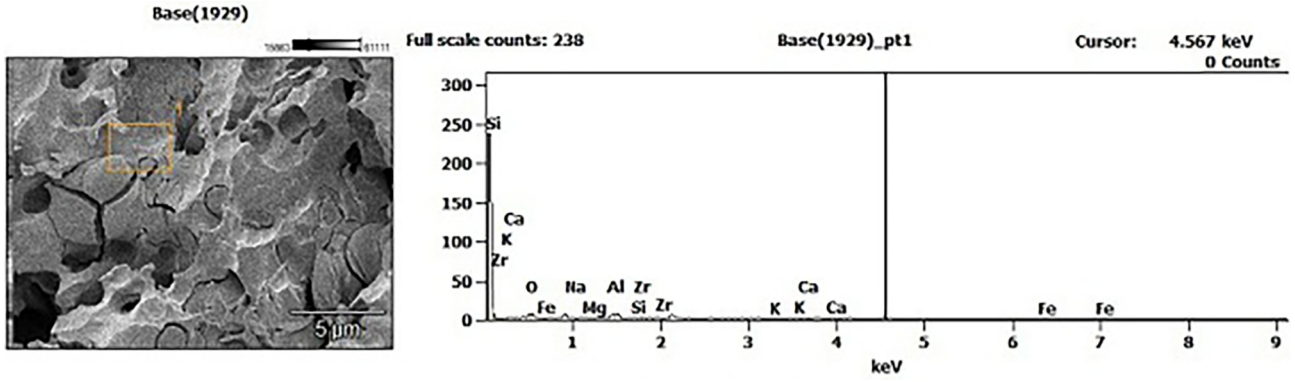

Fig. 7. The SEM results for Al6061 + 10% Basalt + 2% ZrO_2.

3. Corossion test results

The specimens after exposure to corrosion medium, the same sample is dipped in Clarke's solution and gently cleaned with a brush to remove the oxide layer formed on the specimen. Specimens are then washed with distilled water and acetone then it is dried, after drying the specimens were weighed by using digital weighing machine and the final weight is compared with the initial weight. The same procedure is conducted for 240 h with an interval of 48 h. The tabulated results are tabulated. The result of the weight loss with time up to 240 h with intervals of 48hrs is narrated in Fig. 1 (Table 1 Table 2 Table 3 Table 4 Table 5 Table 6).

4. EM results for the test specimen

The specimens are viewed for the crystallographic structure and dispersion of Basalt and Zirconia Particles by SEM and XRD, These results are obtained for all specimens. The specimen SEM and XRD results are intact and are represented. The dispersion of the Basalt and ZrO2 particles are chipped under the action of wear test is also observed in Fig. 2 (The SEM Results for Al6061 + 0% Basalt + 0% ZrO2), Fig. 3 (The SEM Results for Al6061 + 1%Basalt + 2% ZrO2), Fig. 4 (The SEM Results for Al6061 + 4% Basalt + 2% ZrO2), Fig. 5 (The SEM Results for Al6061 + 6% Basalt + 2% ZrO), Fig. 6 (The SEM Results for Al6061 + 8% Basalt + 2%ZrO2) and Fig. 7 (The SEM Results for Al6061 + 10% Basalt + 2%ZrO2).

5. Conclusion

- From the SEM Results the as the material used for corrosion test is a worn out material(Wear Tested Specimen) the cracks and cavities are more which might have leads to little high corrosion rate.
- The Al6061/Basalt/ZrO2 Hybrid Metal Matrix Composites have been successfully evaluated for corrosion test; the two peaks are because of long duration of corrosion in the same 1 M HCl solution media.
- The Al6061/Basalt/ZrO2 Hybrid Metal Matrix Composites have been successfully evaluated for corrosion test of 1 M HCl solution. In which the corrosion is minimum in 0, 8, & 10% and maximum for 4% compared to other. By this we can conclude that as basalt particles powder consist of maximum percentage of SiO2 the corrosion rate has increased rapidly.
- Basalt particulates and Zirconium can be effectively utilized as strengthening materials for light weight Metal Matrix Composites (MMCs). It can supplant other higher density and costly reinforcements. Likewise brings about a 'lighter composite material'. Hence these composites can be used in major applications.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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