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Mechanical Properties and Microstructure of Al-7075-BA Hybrid Composites

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Abstract - *Aluminium 7075 alloy (Al-7075) commonly used in aerospace applications from 7 decades, researchers are concentrating to improve their mechanical behaviour of alloy materials by adding reinforcements like agricultural waste ashes, graphite (Gr), and SiC etc. In present work base material used as Al-7075 alloy. To improve the mechanical properties of base metal, sugarcane baggase-ash (BA) and graphite particles are used as reinforcements. BA reinforcement added 1, 3, 5, 7, 9, 11 & 13wt% in base metal to prepare Al-BA Composites, which shows higher tensile strength and higher hardness. The Gr reinforcement added in base metal 5wt% kept constant with various wt% of BA composites, which shows more enhancements in the mechanical properties of material. The composites and hybrid composites have been fabricated by using stir casting method. The mechanical properties are investigated as per the ASTM standards for prepared specimens. The mechanical properties analysed such as tensile strength, compressive strength, hardness and Impact strength. The microstructure studies were carried out to observe the type of reinforced particle distribution in composites. In this investigation it was observed that, the mechanical strength increased with increasing in wt% of percentage BA reinforcement in base material of composite but less improvement in impact strength. Further, when 5% Gr particles added mechanical strength, impact and interfacial bonding increased in hybrid composites.*

Key Words: Al-7075, Baggase-ash, Graphite, Mechanical Properties, Microstructure.

1. INTRODUCTION

Aluminum alloy hybrid composites are acquiring popularity and have new material properties. Efforts were made to investigate the possible use of hybrid composites having soft and hard reinforcements in a number of industrial and mechanical applications. The accumulation of the reinforcement improves the mechanical properties of Al based hybrid composite, while compared to the base alloy. Although, accumulation of any hard reinforcement to aluminium like SiC, Gr, and ashes etc., which increases the tensile strength, density, corrosion resistance, surface finish, and increases hardness etc. Now a day's agricultural waste sugarcane bagasse ash producing 300-400 million tons of products per year in Karnataka, India, which contains higher amount of SiO2, SiC and other oxides in composition [1], these oxides will be utilized as reinforcement to improve the strength of aluminium alloy material such as high wear resistant, hardness and mechanical strength etc. [2]. Graphite is most important reinforcing element for solid lubrication under dry sliding condition, enhancement in mechanical strength and wettability of the ceramic reinforced hybrid composites [3].

2. LITERATURE SURVEY

The density of aluminium alloy material is very less compared to other metals, it have good quality of corrosion resistance, workability, less melting point (about 650^0 to 800^0C) etc. [7], [8], [9] and [10]. Work was carried out to be aware of micro and macro structural performance of the proposed composites based on boundary surface and interfacial energy evaluation process [5]. The cast composites have higher porosity will shows higher damages in mechanical properties of material and the selection of proper mould design significantly reduce in damages [10]. The characterization of mechanical and tribological properties of Al-alloy with bagasse ash (BA) reinforcement composites was experimental investigated. Increasing hardness effect was analysed on addition of BA reinforcement with varying wt%., however tensile and compressive strength increased [1]. The comparative study was done on different agricultural waste ashes; it was found that bagasse ash (BA) is most dominant compare to other ashes. The composites properties were increases with increasing BA wt%. The chemical composition of BA shows SiO2 higher percentage more than 75% compared to other constituents, which helps enhancement in mechanical properties alloy material [1], [5], [6], [7] and [10]. Al-7075/Gr composites were superior mechanical properties such as yielding strength and vickers hardness etc. [4] and [13]. Also acts as solid self lubricating element under dry sliding condition was analysed on addition of graphite (Gr) reinforcement content with wt.% 5, 10, 15 and 20. The coefficient of friction was decreases with increasing Gr content and mechanical behaviour of composites higher with increasing graphite percentage was observed and compared with conventional alloy. It was observed that, the 5wt% of Gr

reinforcement shows superior results for mechanical properties and especially higher wear resistance [3]. The modified properties of Al–Zn–Gr hybrid composites by using Zn 5, 4, 3wt% and Gr 0, 0.5, 1,1.5wt% reinforcement are make clear as per the design of experimental (DOE) method mechanical properties were increased with less wt% of Zn increasing with more wt% of Gr reinforcement[4]. Study emphasized that tensile and hardness behaviour of Al reinforced with TiB2p composite by using UTM and micro hardness tester. They observed that practical complexity on distribution of uniform reinforcement for Bagasse /Al-alloy composites was discussed [8]. Bagasse ash contains SiC is forms wettability, when this mixed with liquid Al material, it act as natural wetting element SiC forming Al4C3 (aluminium carbide) substances were found that low porosity of material achieved[9].

3. EXPERIMENTAL DETAILS

3.1. Material Selection and Specimen Preparation

3.1.1. Selection of matrix material

Al7075 alloy were selected as matrix material which serves wide verities of application in several engineering fields some of them is automotive and aerospace applications. This alloy shows higher mechanical and tribological properties compared to other series of materials [2]. The synthesis of composites used in this study of Al-7075 alloy shown in table 1.

Table-1. Composition of composite materials.

Sl. No.	Al-7075 %	Graphite %	Bagasse Ash %
1	100	0	0
2	99	0	1
3	97	0	3
4	95	0	5
5	93	0	7
6	91	0	9
7	89	0	11
8	87	0	13
9	94	5	1
10	92	5	3
11	90	5	5
12	88	5	7
13	86	5	9
14	84	5	11
15	82	5	13

3.1.2. Selection of reinforcement material

The agricultural waste bagasse ash (BA) material is free of cost available (size of partial is 0.1-100µm [3]) and graphite (particle size 20–60 µm) [13] reinforcements were used for the preparation of composites with Al7075 based matrix material.

3.1.3. Composite preparation

The section of base alloy composition with graphite and BA reinforcements are as follows. Both graphite and Al7075 alloys were procured from Fenfee Metallurgicals Pvt. Ltd., Bangalore, India, and BA is browed from pandavpura sugar cane factory [13].

1 Al7075 alloy
2 Al7075 alloy + 1%BA
3 Al7075 alloy + 3%BA
4 Al7075 alloy + 5%BA
5 Al7075 alloy + 7%BA
6 Al7075 alloy + 9%BA
7 Al7075 alloy + 11%BA
8 Al7075 alloy + 13%BA
9 Al7075 alloy + 5%Gr + 1%BA
10 Al7075 alloy + 5%Gr + 3%BA
11 Al7075 alloy + 5%Gr + 5%BA
12 Al7075 alloy + 5%Gr + 7%BA
13 Al7075 alloy + 5%Gr + 9%BA
14 Al7075 alloy + 5%Gr + 11%BA
15 Al7075 alloy + 5%Gr + 13%BA

The compositions of Al based hybrid composites were fabricated by using Al furnace. The compositions were melted in the furnace at 750^0C (temperature). The molten Al alloy was stirred by using mechanical rotating stirrer at 200-300 rpm for the duration of 10-15 minutes and then the reinforcement was added in the molten metal. The composites melting temperature of 750^0C maintained and it was then poured in to metallic moulds and allowed for the solidification.

3.2. Experimental Tests

Evaluation of tensile behaviour of casted composites using TUE-C–400 testing machine as per ASTM E8M standards and its relevant features of the equipment are capability is 40T and IS-1828-991. Strain rate constant 0.5mm/min was used during the tests. UTS (Ultimate tensile strength) evaluated. Also compressive behaviour of composites was analysed as per ASTM-E9 standard. Hardness tests were conceded on samples of composites, by applying loads 20-50 grams for a time of 10 seconds by using brinell hardness tester (ASTM E10 standard testing method). Meta test Model SE-B3000-O was used for hardness test. Evaluation of impact behaviour of composites using IT-30 testing machine as per ASTM-E23 standard, all the tests was conducted in Advanced Metallurgical Laboratory, Peenya, Bangalore.

4. RESULT AND DISCUSSIONS

4.1 Microstructural studies for particle distribution

Scanning Electron Microscopy (SEM) image analysis carried out at 400X magnification [11], it was found that BA and Gr reinforcement particles are uniformly distributed in base metal. Also observed that the Gr is mixed with BA particle which decreases the porosity in composites, that is Al-BA composites show more porosity than Al-Gr-BA hybrid composites shows in fig.1. Farouk Shehata et al, Bagasse ash have SiC which act as natural wetting element forms Al4C3 (aluminium carbide) substances, it was found that low porosity of material achieved by the composites [9].

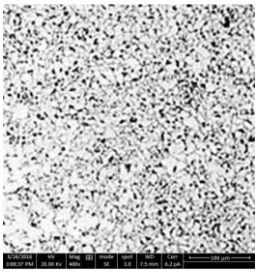
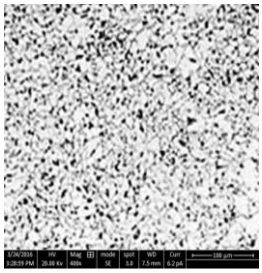


Fig 1. (a)



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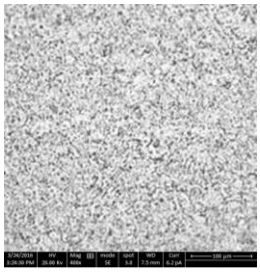

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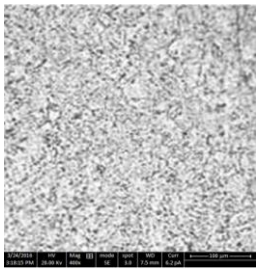

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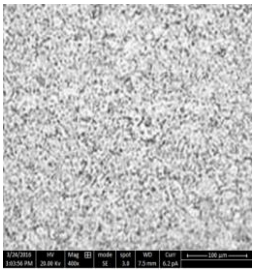

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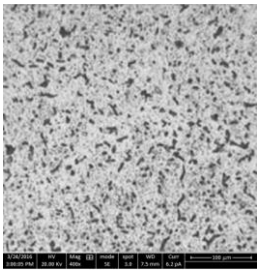

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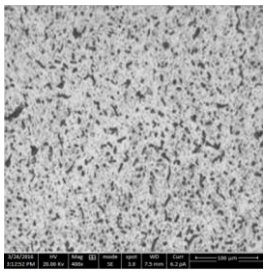

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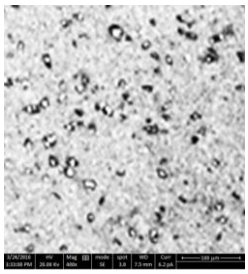


Fig 1. (h)

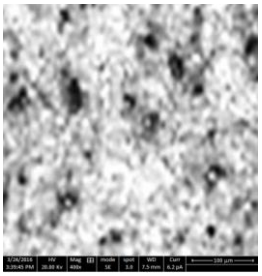
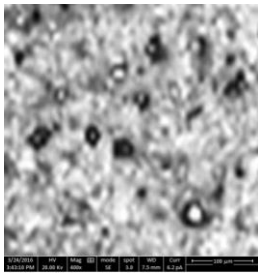


Fig 1. (i)



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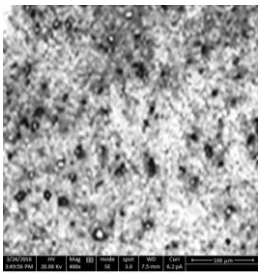

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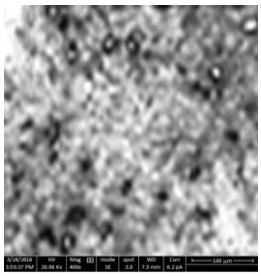

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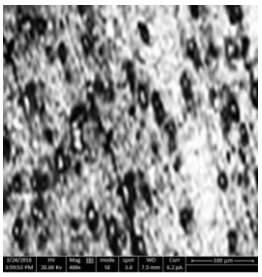

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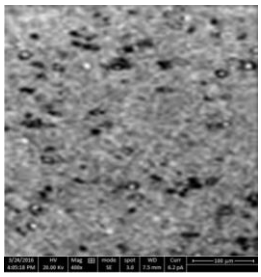

Fig 1. (n)

Figure-1. SEM of composites and hybrid composites reinforcement distribution (a) Al+1%BA, (b) Al+3%BA, (c) Al+5%BA, (d) Al+7%BA, (e) Al+9%BA, (f) Al+11%BA, (g) Al+13%BA, (h) Al+1%BA+5%Gr, (i) Al+3%BA+5%Gr, (j) Al+5%BA+5%Gr, (k) Al+7%BA+5%Gr, (l) Al+9%BA+5%Gr, (m) Al+11%BA+5%Gr and (n) Al+13%BA+5%Gr.

4.2 EXPERIMENTAL RESULTS

4.2.1. Tensile Test Results

The tensile test was conducted as per the ASTM E8 Standard for composites. Aluminum with bagasse ash reinforced composites increasing yielding strength with increasing BA content. Al /5% graphite with bagasse ash reinforced hybrid composites increasing in yielding strength with increasing BA content more than Al-BA composites and base metal (Fig.2(b)). The maximum ultimate tensile strength (UTS) is 201.5MPa for Al-BA composite material which lesser than Al-5%Gr-BA hybrid composite UTS is 241.9MPa represented in fig.2. Fig.3 shows yielding strength of composite has maximum 159.97MPa and hybrid composites has 161.78MPa which much higher than base alloy.

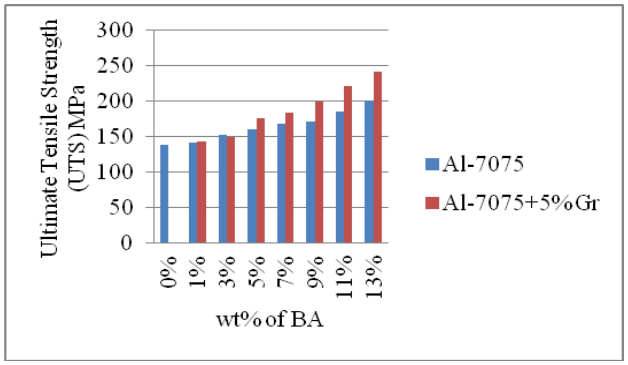

Figure-2. Variation of UTS

Figure-3. Variation of yielding strength

4.2.2. Harness test results

Brinell hardness tests were conducted on hardness tester for composites. Al with increasing wt% of bagasse ash reinforcement in composites was increasing BHN. Al /5% graphite with same increasing wt% of bagasse ash reinforced hybrid composites were shows much higher BHN. The both composition was shown higher hardness whereas better results observed in hybrid composites (Al-5%Gr-BA) fig.4. The BHN of hybrid composite is 19.62times higher than Al-BA composite material.

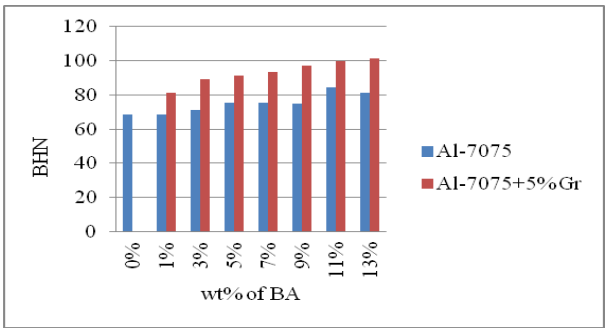

Figure-4. Variation of BHN

4.2.3. Compressive Test Results

The compressive tests are conducted as per the ASTM E9 standard for composites. Al with BA reinforced composites increases in compressive strength with increasing BA content. Al/5% graphite with bagasse ash reinforced hybrid composites increase in compressive strength with increasing BA content Fig.5. Hence, it gives higher compressive strength of Al-5%Gr-BA hybrid composite than Al-BA composite material. The maximum compressive strength is 607.9MPa for Al-BA composite material which lesser than Al-5%Gr-BA hybrid composite compressive strength 689.5MPa. Comparatively compressive strength of hybrid composite is 11.83 times higher than Al-BA composite material. The hybrid composites (Al-5%Gr-7%BA) shows 21.55% higher compressive strength compared to conventional Al-7075.

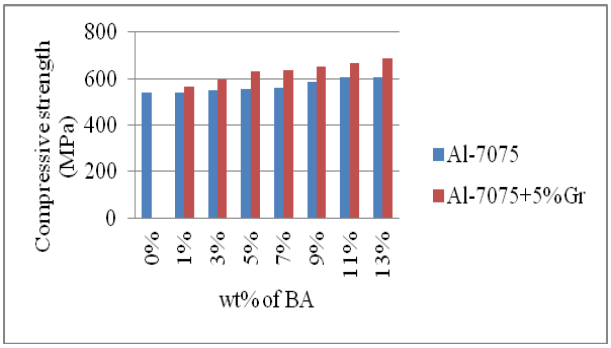

Figure-5. Variation of Compressive strength

4.2.5. Impact Test Results

The impact tests are conducted as per the ASTM E23 standard for composites. Al-5%Gr-BA hybrid composite have higher impact strength than that of Al-BA composites fig.6. Impact strength was decreased with increasing BA wt% in composites, whereas hybrid composite strength increased (fig.6). The hybrid composite impact strength is 18.8% higher than Al-BA composite material. The hybrid composites (Al-5%Gr-7%BA) shows 14.5% higher impact strength compared to conventional Al-7075.

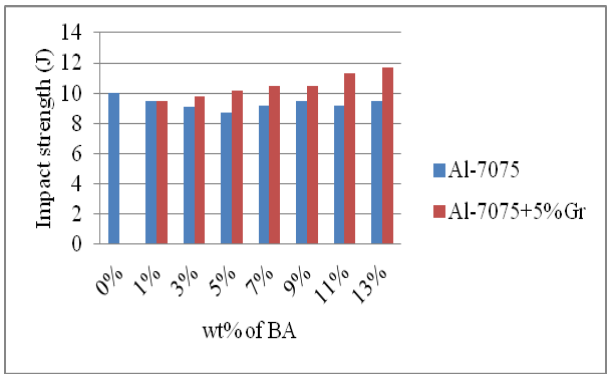

Figure-4. Variation of Impact strength

4.3. DISCUSSION

The AL-7075 base composites fabricated with two compositions, first composition made BA reinforcement

without graphite content. Second composition made with constant 5% of graphite for each of varying wt% BA hybrid composites. The SEM image analysis shows uniform distribution of reinforcement in base alloy material, also observed that Al-BA composite have more porous and Al/5%Gr-BA hybrid composite have less porous in nature. The first set of composites was gives the value of tensile strength 5.8% lesser than hybrid composites. Ultimate tensile strength of hybrid composition gives 16.9% more than Al-BA composites. Al-BA composites are less ductile and porous in nature whereas hybrid composites are higher ductile and porous in nature. The compressive strength of hybrid composite is 21.55% higher than Al-BA composite material. The BHN of hybrid composite is 19.62% higher than Al-BA composite material, both the compositions of composites was observed that more increasing hardness which have better results and also observed that tensile strength is increased simultaneously higher in hybrid composites whereas in Al-BA composites less increased. The impact strength of hybrid composite is 18.8% higher than Al-BA composite material. It was found that Al-5%Gr-BA hybrid composites have increased in mechanical properties compared to conventional Al-7075

CONCLUSIONS

Composites are prepared successfully by using stir casting method. The mechanical behavior of the fabricated composites was observed that, strength will be increases with increasing in percentage of BA reinforcement in Al-7075 matrix. Al-7075-BA composite was gives slightly increasing in tensile strength, compressive strength, impact strength and hardness with increasing wt% of BA. Al-5%Gr-BA hybrid composites more higher yielding strength, UTS, hardness, compressive strength and impact strength compared to Al-7075-BA composite. SEM study was found that, grain distribution will uniformly take place throughout the matrix material. Composite have more porous and hybrid composite have less porous in nature. Finally it was observed that Al-5%Gr-7%BA hybrid composite superior in mechanical and microstructure properties compared to Al-BA composites and conventional alloy material.

Feature scope

Chemical composition test, Fractography, Wear test, Corrosion test etc. will be carried out for my further research work.

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