Experimental Investigation of Mechanical properties of Bagasse Ash and SiC reinforced Al 7075 alloy matrix hybrid composites manufactured by stir casting method

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Abstract

In present investigation, The fabrication of Al alloy 7075 based matrix hybrid composites with reinforcement particals of sugarcane bagasse-ash with varying (3%,6%,9%) percentage and SiC 3% is constant. The aluminium matrix hybrid composites have been fabricated by stir casting method at 800°C and magnesium (1%) is added to overcome the wetting problem between reinforcement and liquid aluminium metal. Sugarcane bagasse-ash is one of the most inexpensive and low density reinforcement available in large quantities as agriculture waste by-product during combustion of waste sugarcane. Comparision of Al 7075 alloy is done with SiC reinforced metal matrix composite and both SiC and bagasse-ash reinforced hybrid matrix composites by performing tests like Brinell hardness test, dry sliding wear test, tensile strength test. It was last observed that sample 3 (Al7075 + 3% SiC+ 3% Bagasse ash) is found to be efficient as com -pared to Un-reinforced matrix.

Keywords:- Aluminium matrix composite, mechanical properties, Bagasse ash, SiC, microstructure analysis

Introduction

In many industrial applications, the most important parameter in material selection is specific strength. For example it is the critical design criterion in rotating machinery components. Aluminum is a natural candidate for this type of application because of its low density. Recently hybrid composites are more popular and cover more than one material property. Attempts were made to explore the possible use of composites having hard and soft reinforcements in several technological applications. The addition of the reinforcement enhances the mechanical properties of aluminium based composite, when compared to the matrix alloy. However, addition of any hard reinforcement to aluminium reduces the corrosion resistance, electrical conductivity and surface finish, etc. Bagasse ash (BA) is rich in SiC, which helps to increasing the strength of aluminium such as high hardness, high wear resistant and also good mechanical properties including high strength, thermal conductivity, etc. Al 7075 possesses very high tensile strength, higher toughness and are preferred in aerospace and automobile sectors . Whilst the use of composites will be a clear choice in many instances, material selection in others will depend on factors such as working lifetime requirements, numbers of items to be produced (run length) ,complexity of product shape, possible savings in assembly costs and on the experience & skills the designer in tapping the optimum potential of composites. In some instances, best results may be achieved through the use of composites in conjunction with traditional materials.

Literature review

The purpose of this literature review is to provide the information about the utilization of Al metal matrix with reinforcement and particle as reinforcement in the preparation of composites for various applications. the study of mechanical properties of Al- Red Mud and Silicon Carbide Metal Matrix Composite (MMC) of Aluminum alloy of grade 7075 with addition of varying weight percentage composition such as SiC8%+Al7075, SiC6%+Red mud2%+ Al7075, SiC4%+Red mud 4%+Al7075, SiC2%+Red mud6%+Al7075, Red mud 8%+Al7075ed mud and Silicon Carbide particles by stir casting technique. The experimental result reveals that the combination of a matrix material with reinforcement such as SiC and Red mud particles, improves mechanical properties like tensile strength, compressive strength, hardness and yield strength [1]. Tribological and mechanical properties of Al-7075 alloy with graphite (Gr) reinforcement composites were investigated. Self-lubricating properties and dry sliding condition were analysed on added reinforcement content of graphite with varying wt.% as 5,10, 15 and 20. It was observed that the average coefficient of friction is decreases with increasing of graphite content and mechanical properties of composites decrease with increasing graphite percentage as compared with conventional alloy. 5% of graphite reinforce-ment shows most prominent results [2], influence of Gr for wear behaviour of Al 7075/Al2O3/5 wt.% Gr hybrid composite (2, 4, 6 and 8 wt.% of Al2O3) found that the ceramic phase weight percentage increased and finally suggested the wear behaviour of hybrid composites contains graphite that show superior resis-tance to wear [3]. Characterization of Al-7075 unreinforced and reinforced (7wt% of SiC and 3wt% Gr hybrid composite) were used to understand the tribological properties of the proposed materials .Un-lubricated pin -on -disc wear testing machine at loads 20-60N, speed 2–6 m/s and sliding distances 2000–4000 m was used to know the specific wear rate and observed that the value of the hybrid composite is lower than that of the unrein forced Al-7075 alloy. Worn out surface is observed by using scanning electron microscope and was found that the effect of load on specific wear rate is most significant factor followed by sliding speed and sliding distance [4]. The modified mechanical and tribological properties of Al–SiC–Gr hybrid composites by using both reinforcement with equal weight fraction are explained as per the design of experimental technique wear were increased beyond the 7.5 wt% of reinforcement [5].Studies on technical difficulties of uniform reinforcement distribution for SiC/Al alloy MMCs were discussed.

Wettability between substances was found good and low porosity of material was achieved [6]. Studies on Al6061-SiC and Al7075-Al2O3 Metal Matrix Composites, The experimental investigation Micro hardness of the composites found increased with increased filler content and the increase in hardness of Al6061-SiC & Al7075-Al2O3 composites are found to be 60-97VHN & 80-109VHN respectively ,tensile strength properties of the composites are found higher than that of base matrix and Al6061-SiC composites superior tensile strength properties then that of Al7075- Al2O3 composites and the studies in overall it can be concluded that Al6061-SiC exhibits superior mechanical and tribological properties [7].) investigated the influence of graphite on the wear behaviour of Al 7075/ Al2O3/5 wt. % graphite hybrid composite by using liquid metallurgy route. The mechanical and tribological properties of the Al 7075/Al2O3 graphite hybrid composites were found to be increased by increased weight percentage of ceramic phase and its wear resistance properties also found to be superior [8].

3. Experimental details

3.1 Material selection

3.1.1 Matrix alloy

Aluminum alloy 7075 is an aluminum alloy, with zinc as the primary alloying element. It is strong with strength and has good fatigue strength and average machinability. Alloy7075 is heavily utilized by the aircraft and ordnance industries because of it superior strength. The composition and various properties of Al7075 are shown in table 1.

Table 1 chemical composition of Al7075[9]

Chemical composition	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
Al7075	0.4	0.5	1.6	0.3	2.5	0.15	5.5	0.2	Remaining

3.2 Reinforcements

3.2.1 Bagasse-Ash

Sugarcane bagasse ash is a byproduct of sugar factories found after burning sugarcane bagasse which itself is found after the extraction of all economical sugar from sugarcane[10]. It is an industrial waste which is used worldwide as fuel in the same sugarcane industry. These sugarcane bagasse ashes (SCBA) have been chemically, physically and miner logically characterized in order to evaluate the possibility of their use as a cement replacing material in concrete industry[11].

Preparation of Sugarcane Bagasse ash

The sugarcane was collected from Yangon region, Myanmar pictured in Fig.1 (a) The sugarcane waste, bagasse is dried under sunlight to reduce the moisture content in bagasse shown in Fig.1(b). The dry bagasse was ground with a grinding machine and placed inside electric furnace. After firing at 1200^{o}C for 3h and 6h, bagasse ash was shown in Fig.1(c) was obtained

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(a) (b) (c)

Fig 1 . Bagasse Ash (a) Dry Bagasse,(b) Bagasse ash (c) Fine bagasse ash

3.2.2Silicon Carbide

Silicon Carbide is the only chemical compound of carbon and silicon. It was originally produced by a high temperature electro-chemical reaction of sand and carbon. It is used in abrasives, refractoriness, ceramics, and numerous high-performance applications [12]. The partical size range is 200 micrometer is used.

3.3 Composite Preparation

Al matrix hybrid composite were fabricated by stir casting method using furnace. Three types of composites were prepared as reported below.

1. Al7075 alloy + 0%BA + 0%SiC
2. Al7075 alloy + 0%BA + 3%SiC
3. Al7075 alloy + 3%BA + 3%SiC
4. Al7075 alloy + 6%BA + 3%SiC
5. Al7075 alloy + 9%BA + 3%SiC

3.4Experimental work

The Stir casting method (also called liquid state method) is used for the aluminium matrix hybrid composite materials fabrication, in which a dispersed phase is mixed with a molten matrix metal by means of mechanical stirring. The liquid composite material is then cast by conventional casting methods and may also be processed by conventional metal forming technologies.

In this study, the aluminium alloy matrix, aluminum alloy-SiC , aluminium alloy-SiC-Bagasse ash metal matrix hybrid composite was prepared by stir casting route. For this we have chosen 1000gm of commercially pure aluminum and desired amount of SiC, Bagasse ash, SiC-Bagasse ash mixtures in powder form. The Bagasse ash and SiC and their mixture were preheat -d to 300°C for three hours to remove moisture. Pure aluminum was melted in a furnace. The melt temperature was raised up to 800°C and then the melt was stirred with the help of a mild steel stirrer. The stirring was maintained between 5 to 7 min at an impeller speed of 200 rpm. To increase the wettability, 1% of pure Mg was added with all composites.

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3.5Vickers Hardness test

Vickers hardness tests were carried out on samples of both unreinforced alloy and its composites, by applying 1000 kgf for a period of 15 seconds using Vicker indenter hardness. Test conducted at 3 points on specimen. Actual sample shown in fig.2

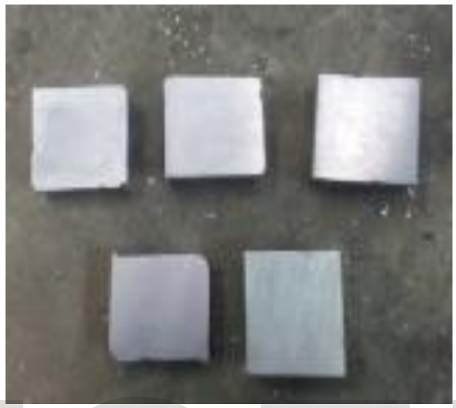


Fig.2 Actual sample of hardness

3.4Tensile test

Tensile tests of developed aluminium matrix hybrid composites were evaluated using tests using a computerized Heico UTM (model 590.15) testing machine which is shown in Fig.3as per ASTM E-8M Standard (sub size specimen). the test was conducted in Gbpec ghurdauri. The computerized Heico UTM (model 590.15) testing tensile testing equipment is shown in Fig.3

Fig. 3 Ultimate Tensile Strength Machine **Fig.4** Actual tensile test specimen

3.5 Microstructural Characterization

The composites produced were examined by optical microscope to analyze the microstructure. A section was cut from the castings, which is first belt grinded followed by polishing with different grade of emery papers. After that they were washed and again cloth polishing of the sample was done. After etching they were examined for microstructure under optical microscope at magnification.sample show in fig.5

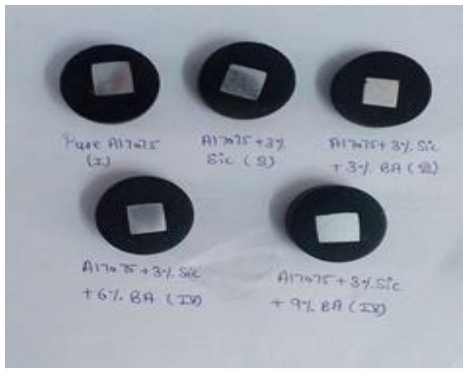


Fig.5 Polished sample of microstructure

4 Result and discussion

4.1 Effect of hardness

The hardness of the aluminium alloys is increased with the addition of Bagasse ash and SiC reinforcements. Table 2 show the increase in the hardness is due to the addition of 3 wt% SiC particles and 3% Bagasse ash, which can be attributed to the fact that the SiC and BA possess higher hardness and its presence in the matrix improves the hardness of the composite. This is shown in Fig.7

4.2. Effect of tensile strength

Fig shows graph showing tensile strength of composite. It has been found that the peak stress is 315.27 Mpa for pure aluminium whereas the peak stresses of different composites are more than that of pure aluminium. From the tensile results, it is observed that the tensile strength of AMCs is greater than unreinforced Al. Table 2 Increase of tensile strength in AMCs can be attributed due to applied tensile load transfer to the strongly bonded reinforcements of 3% Sic+3% Bagasse-Ash in aluminium alloy matrix. The increase the tensile strength is due to the addition of 3wt%SiC+3wt%BA.This is show in Fig.6

4.3 Optical Micrographs of composites

The morphology, density, type of reinforcing particles and its distribution have a major influence on the properties of particulate composites. The variables that govern the distribution of particles are solidification rate, fluidity, type of reinforcement and the method of incorporation. It is necessary to distribute particles uniformly throughout the casting during production of particulate composites. The first task is to get a uniform distribution of particles in the liquid melt and then to prevent segregation/agglomeration of particles during pouring and progress of solidification. One of the major requirements for uniform distribution of particles in the melt is its wettability. Addition of magnesium improves the wettability.

It is observed that particles were not uniformly distributed in the case of Al/(3% SiC), Al/(3% SiC-3% BA), Al/(9% Bagasse ash-3% SiC). Here, the particles were segregated at the selected places of the plates. The outer of the casting contained few particles. This is due to the gravity regulated segregation of the particles. But uniform distributions of particles were observed in the micrographs of aluminium in the presence of 3%SiC-6%Bagasse ash mixture at various concentrations.

Table 2 Experimental results of mechanical properties

Sample	Al alloy 7075 (wt%)	Composites			Results	
		SiC	Bagasse Ash	Mg (wt%)	Tensile strength(Mpa)	Vicker hardness
1	100	0%	0%	1%	315.27	94.3
2	97	3%	0%	1%	331.94	109.3
3	94	3%	3%	1%	338.33	125.7
4	91	3%	6%	1%	278.34	80.7
5	88	3%	9%	1%	283.33	98.1

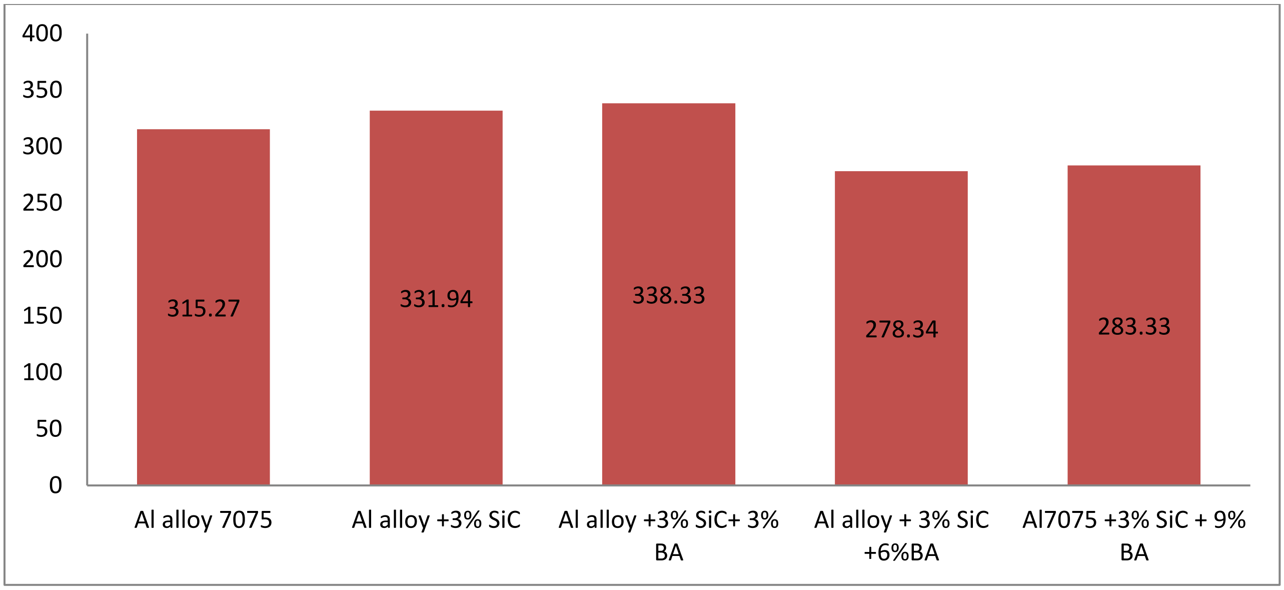


Fig.6 Graph showing tensile strength of composites

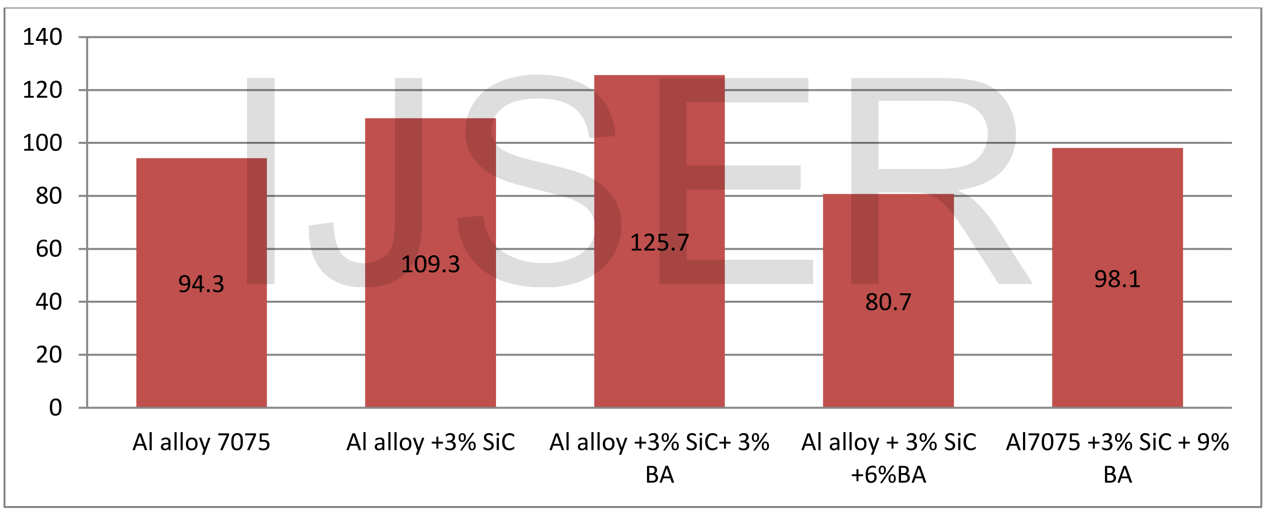
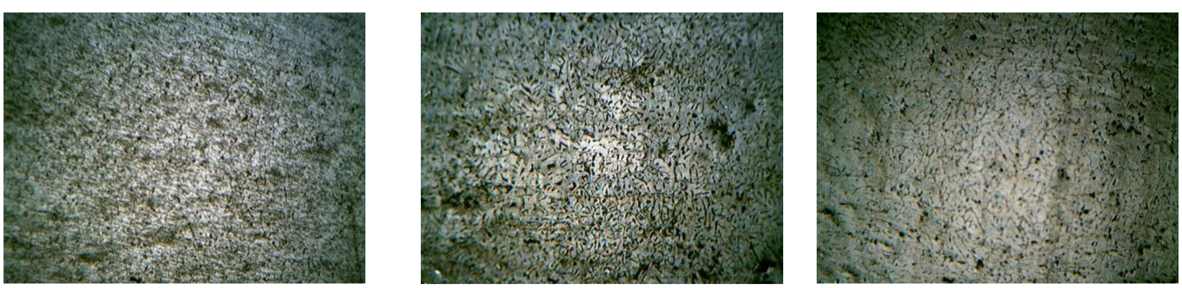
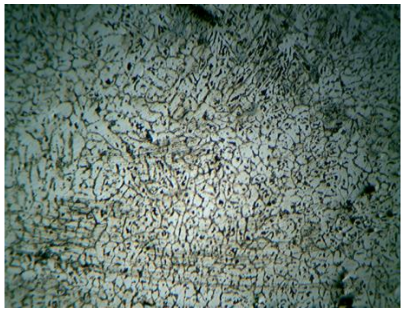


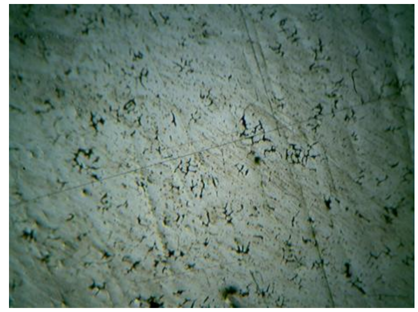
Fig.7 Graph showing Hardness tests results



(a) pure Al7075 (b) Al7075+3% SiC (c) Al7075+3%SiC+3%BA



(d)Al7075+3%SiC+6%BA



(e)Al7075+3%SiC+9%BA

Fig.8 optical micrograph of sample

5. Conclusion

Pure Al ,Al-SiC, Al-Bagasse-ash-SiC, with various compositions were successfully fabricated stir casting process. Wetting of reinforcements with the aluminium matrix was further improved by the addition of magnesium.

Based on the experimental observations the following conclusions have been drawn:

- It has been seen that the different mechanical properties of metal matrix in a composite is greatly influenced with the addition of reinforcements.
- In hardness test, presence of 3% wt SiC + 3% Sugarcane Bagasse ash harder particle increases the hardness of Al7075 to a greater value comparing to the metal matrx hybrid composite, keeping un equal total percentage weight of reinforcements.
- In tensile testing, the value for the composite having Al7075 +3% Sic +3%SC BA comes to be the highest. This shows that the presence of Sic particles make the composite increases the brittleness in the samples causing uneven fractures.
- Microstructure images show the excellent interfacial bonding and particles are well dispersed in hybrid matrix when added 3% SiC+6%SCBA.

From the above results we can conclude that instead of Al-SiC composites and the Al-SiC-SCBA ash composites could be considered as an exceptional material in sectors where lightweight and enhanced mechanical properties are essential.

5.1Scope of the Future Work

Although metal matrix composites and their hybrid form has a wide scope for the research work in future making hybrid composites more applicable in different areas. The present work can be extended with some recommendations below:

- The present reinforcements, Sic and Bagasse ash can be added to other grades of Aluminium and can be compared with others.

- Present work is done by using stir casting method which consists of several defects. The same work can be done by other fabrication techniques too and result can be compared.
- Other than Sic and Bagasse ash the reinforcements such as TiB2,WC,Zircon,wallnut ash, fly ash, Rice husk ash, wheat husk ash,eggshell,B_4C etc. can be added to investigate the mechanical properties of Al7075.

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