

Evaluation of Wear Properties of Heat-treated Al 7075/Graphite Powder/Bagasse ash Hybrid Metal Matrix Composites

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ABSTRACT

This research work investigated the influence of graphite powder on the wear behavior of Al 7075/Graphite Powder (Gr)/Bagasse ash (BA) hybrid composite. The investigation reveals the effectiveness of incorporation of graphite powder in the composite for gaining wear reduction. The Al 7075 (Aluminium alloy 7075) reinforced with graphite powder and Bagasse ash were investigated. The conventional liquid casting technique was used for the fabrication of composite material and subjected to T6 heat treatment. The reinforcement content was chosen as 1, 3, and 5wt. % of graphite powder to identify its potential for self-lubricating property under dry sliding conditions. Hybrid composite is processed at 1wt% of Gr with 2, 4 and 6wt% of BA. The effect of load on dry sliding wear rate and coefficient of friction performance of Al 7075 casting alloy and its composites was evaluated by using a pin-on-disc with two different loads with constant speed at room temperature. Wear tests were conducted by using pin on disc apparatus to evaluate the tribological behaviour of the composite and to determine the optimum content of graphite powder for its minimum wear rate. The wear rate decreases with addition of graphite powder content and reaches its minimum at 5wt. % graphite. The coefficient of friction decreases with addition of graphite content and was found to be minimum at wt. 5% graphite. The wear properties of the hybrid composites containing graphite exhibited the superior wear-resistance properties.

Keywords : Wear rate, Friction, Al7075, Bagasse ash, Graphite powder (Gr)

I. INTRODUCTION

This research is a compilation of the overview of the research work and characteristic aspects of the evaluation of the composite materials fabricated utilizing Aluminium as the matrix phase and

Graphite powder and Bagasse ash as the reinforcement phases.

The utilization of advanced performance of wear resistance material for various tribological function in the development of hybrid composite materials. The use of ceramic reinforcement in monolithic Al matrix, composite has increases in mechanical and

tribological properties appreciably. The recent type of composites are known as hybrid composites, in which properties of more than one suitable reinforcement have been exploited to improve the overall properties of composite including tribological properties[1-2]. This paper give a current development about tribological properties of hybrid composites

The recent development for potential applications is to optimize the mechanical properties and tribological properties of MMCs. AMMCs (Aluminum metal matrix composites) reinforced with discontinuous dispersoid in the forms of fibers, whiskers, and particulates reveal amplify strength significance at good wear resistance, low coefficient of friction, low thermal expansion and stiffness compared to base alloys. AMMCs has application in automobile engine block pistons and brake drum. These automotive engine components are subjected to dry sliding wear [3-4]. Wear resistance of aluminum (Al) alloys are improved by introducing particulate reinforcement such as SiC[5-7], Al_2O_3 [7-8], TiC [6, 9], Beryl [10], Hence AMMCs are possible materials for tribological application [10-14]. The level of enhancement in the dry sliding wear resistance of particulates reinforced Al- matrix composites depends on type of reinforcement used, manufacturing technique and contact condition. The interfacial bond strength, mechanical properties of matrix and reinforcement are essentially affect on wear resistance of composites [4, 7, and 11]. The two major types of tribological factor control the friction and wear behaviour of Al based composites are physical and mechanical factors [12-13]. Many researchers and investigators stated that, wear performance of SiC , Al_2O_3 , Gr and BA particles reinforced composites are shows better tribological properties hybrid composites.

Kok and Ozdin[14] investigated the effect of Al_2O_3 particle content and size on the wear behavior of

Al_2O_3 particle reinforced 2024 aluminium alloy composites fabricated by vortex method. **Surappa et al. [15]** have studied the influence of 5 vol. % Al_2O_3 particles addition on the wear resistance of hyper eutectic Al-SiC alloys.

Yu et al. [16] have studied the effects of applied load and temperature on the dry sliding behavior of Al 6061/SiC composites, **Liang et al. [17]** have identified that the MMCs containing SiC particles exhibit improved wear resistance. **Reda et al. [18]** and **Clark et al. [19]** have reported that Pre-aging at various temperatures improves the hardness, tensile properties and electrical resistivity of Al 7075.

Kim et al. [20] concluded that the hardness of aged Al 7075 alloy was increased. **Doel and Bowen [30]** have reported the improved tensile strength and lower ductility of Al 7075 reinforced with SiC particles than that of unreinforced, Komai et al. [21] have identified superior mechanical properties of Al 7075-SiC composites.

Generally lubricant is externally added to reduce the wear. This poses the problem when the materials need the periodic applications of lubricant particularly to wear parts which are difficult to access. For such applications self-lubricating materials are preferred because the solid lubricant contained in them can be automatically released during the wear process to reduce the wear. Graphite is one of the most widely used solid lubricant materials. Earlier researchers [22-25] have already focused their investigation on applications of aluminium graphite composite. There are also earlier reports from some investigators [26-27] who identified the trend that aluminium graphite composite containing the small amount of graphite exhibit superior wear properties over the base alloys. The limitation with the aluminium graphite composite is in using graphite as a solid lubricant whose introduction results in the loss of strength of the composite.

II. MATERIALS PROCUREMENT

1. ALUMINIUM 7075 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. Alloy 7075 is heavily utilized by the aircraft and ordnance industries because of its superior strength.



Fig.1: Aluminum 7075 Ingots

2. GRAPHITE POWDER

Graphite is a form of elemental carbon. Graphite is used in several fields due to its electrical conductivity and chemical properties. Synthetic graphite is a manmade essence contrived by the heavy temperature processing of amorphous carbon materials. The types of amorphous carbon used as precursors to graphite are many and can be consequent from coal, petroleum, or natural and synthetic organic materials. In a few cases graphite can constant be manufactured by the direct precipitation of graphitic carbon from pyrolysis of a carbonaceous gas such as pyrolytic graphite (acetylene). One important commonality between all graphite precursors is that they must contain carbon.



Fig.3: Graphite powder

3. 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. 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 mineralogically characterized in order to evaluate the possibility of their use as a cement replacing material in concrete industry.



Fig.2: Fine Bagasse Ash

III. EXPERIMENTAL DETAILS

Composite is picked as matrix material inferable from its wide application in numerous designing divisions including car and aviation areas. Further, this composite displays great quality and formability. Graphite exhibits the properties such as high rigidity, low thickness, low rubbing and wear resistance and high thermal conductivity. The mixture structure of

composites utilized as a part of the present study is accounted for in the Table 1. Both Graphite and Al7075 combinations were acquired from Fenfe expense Metallurgical, Harohalli, Bangalore, India. What's more, bagasse fiery debris is found in mandya sugar stick industrial facility.

The composites are manufactured by following steps:

1. Casting.
2. Machining.
3. Testing.

1. Casting

The microstructure of any material is a complex function of the casting process, subsequent cooling rates. Therefore, composites fabrication is one the most challenging and difficult task. Stir casting technique of liquid metallurgy was used to prepare Al 7075 and Al 7075 Hybrid composites.

Ingots of Al-7075 amalgam are set in heater and heater is warmed up to 800°C. Refer Fig 4 Ascertained amounts in weight rate are filled in the liquid Al-7075 and mixed utilizing zirconium covered spoon. All around mixture composites are filled in the die, which is as demonstrated in the fig 4. The melting range of Al 7075 alloy is of 700 – 800°C. A known quantity of Al 7075 ingots were loaded into the Graphite crucible of the furnace for melting. The melt was super-heated to a temperature of 800°C and maintained at that temperature. The molten metal was then degassed using Hexo-Chloro ethane tablets for about 8min.



Fig. 4: A stir casting setup, consist of a Coke fired Furnace and a stirrer assembly, which was used to synthesize the composite.

Table 1: Percentage of Reinforcements.

Specifications	Reinforcements		
	Al 7075 in %	Graphite Powder in %	Bagasse Ash in %
A1G2B	97	1	2
A1G4B	95	1	4
A1G6B	93	1	6
A3G2B	95	3	2
A3G4B	93	3	4
A3G6B	91	3	6
A5G2B	93	5	2
A5G4B	91	5	4
A5G6B	89	5	6

2. Machining

After the casting is done, castings are machined according to ASTM standards on highly sophisticated lathe. The turning operation carrying on lathe is shown in Fig 5. As per the ASTM standard G99-95 wear specimen is machined as shown in Fig-6.



Fig 5 Turning operation carrying on lathe



Fig 6 Wear test specimen

3. Testing

Wear Test

According to ASTM G99-95 standards, the wear tests were conducted using Pin-on-disc apparatus (Figure 7) at room temperature (30°C) and humidity 60-65 %.The tests were conducted at constant 300rpm sliding speed and 0.5kg and 1kg applied loads and with constant sliding distance 2637.600 m. Pins with 6mm diameter and 30 mm height were used for the Wear test. The surface of the pin was polished and was rotated against an OHNS(Oil Hardened Nickel Steel) disc which was heat treated to a hardness of 62 HRC. The wear tests were conducted after the initial run in period when the pin specimen was entirely in contact with the disc surface. The wear rate was calculated using weight loss method. The weight of the each specimen was measured using an electronic weighing balance with resolution of $\pm 0.1\text{mg}$ [2].

Element	Symbol	Composition % in Al 7075
Zinc	Zn	5.4
Copper	Cu	1.42
Manganese	Mn	0.12
Magnesium	Mg	2.42
Ferrite	Fe	0.42
Chromium	Cr	0.21
Aluminium	Al	Remaining

Table 2 Chemical composition of Al 7075.

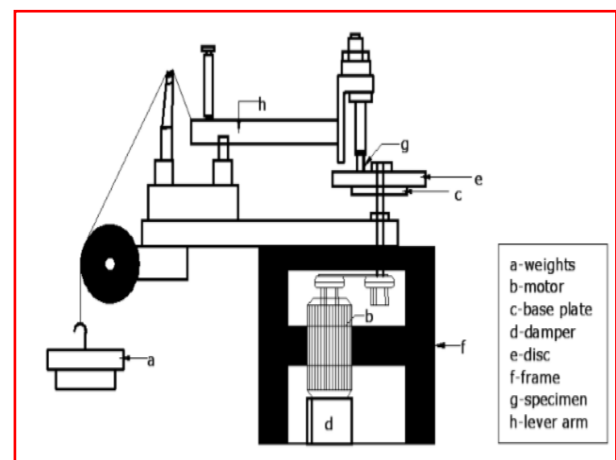


Fig.7 A schematic diagram of pin on disc apparatus

HEAT TREATMENT

T6 Heat Treat Process

T6 heat treatment of cast specimens offers increase in hardness and other mechanical properties, which is often required for many applications. The T6 heat treat is a two-step process. The castings are first allowed to cool naturally and are then heated at an elevated temperature in one of our high temperature ovens. After a set period of time the castings are quickly quenched. The castings are then moved to one of our low temperature ovens for the second step of the process.

In order to develop the correct balance of mechanical properties, it was thought essential to subject the test casting to an optimized thermal treatment (viz. solution heat treatment and quenching). Test samples of suitable length were solutionized in a heat

treatment furnace for a temperature of $525^{\circ}\text{C} \pm 50^{\circ}\text{C}$ for duration of 5 hours. After solutionizing the samples were immediately quenched in water kept at room temperature, stored in the tanks below the furnace. The quenching was done strictly within 15 seconds of opening the furnace door.

The specimen (as cast condition) were subjected to the following heat treatment conditions.

- The castings are first allowed to cool naturally and are then heated at an elevated temperature of 525°C for 5 hrs.
- Quenching in water at a temperature of 60°C

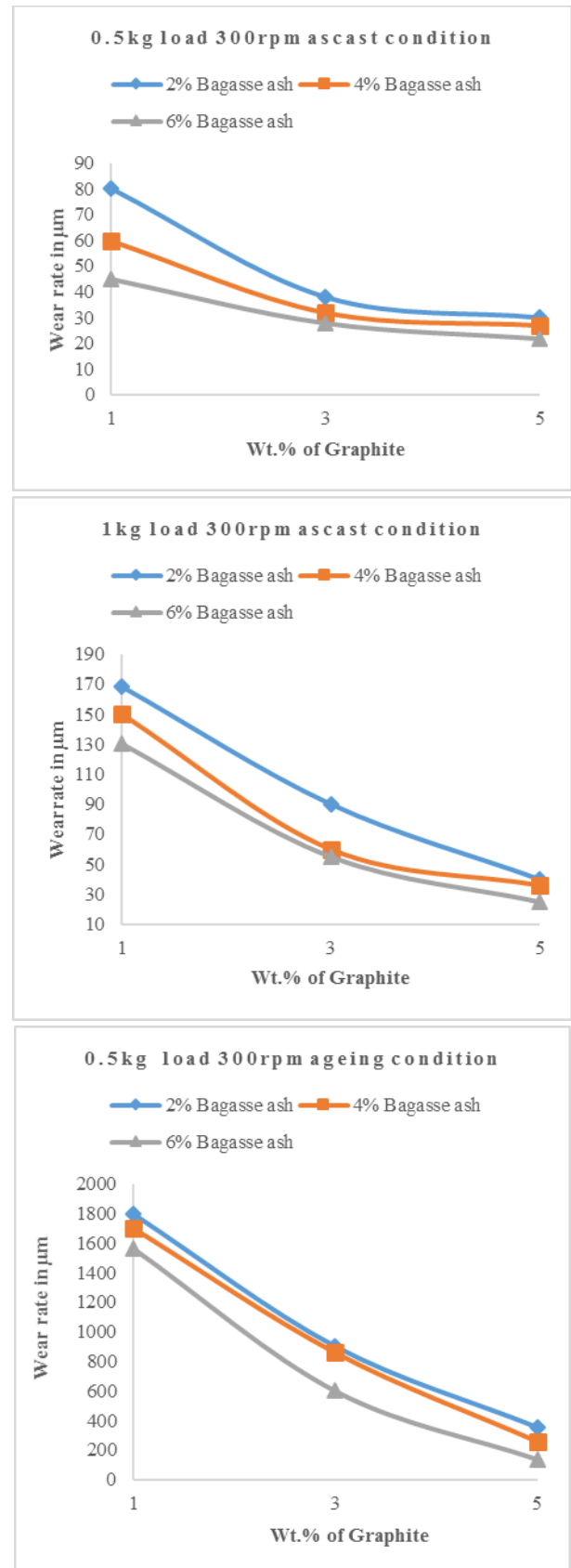
IV. RESULTS AND DISCUSSIONS

Wear rate and Coefficient of friction

Wear rate and coefficient of friction of composites has observed experimentally based on effect of load and effect of reinforcement. Decreasing wear rate with increasing in load and reinforcement, increasing in wear rate with increasing in sliding speed and distance.

Wear loss is decreased with the increased reinforcement weight fractions at any applied load. Hence it is very much clear that shows in figure-2 (a) and (b) and figure 3 (a) and (b) can be concluded that wear resistance increased and friction decreased of hybrid composites with the increasing reinforcement fractions.

1. Effect of wt. % of reinforcement (Graphite and Bagasse ash)



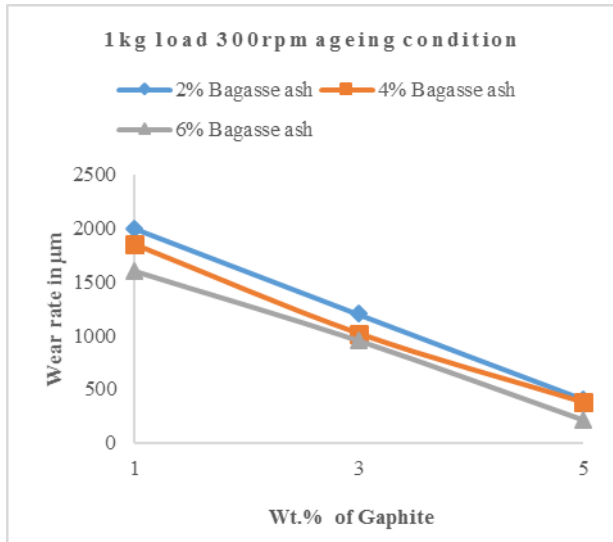


Figure 2 (a): Effect of Wt. % of reinforcement on Wear Rate

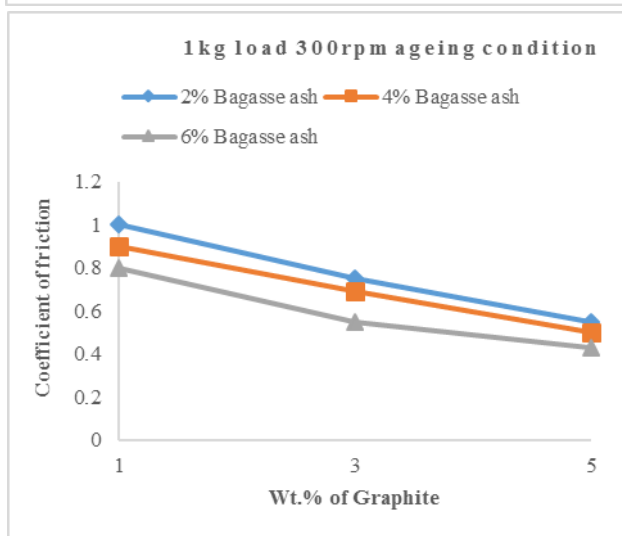
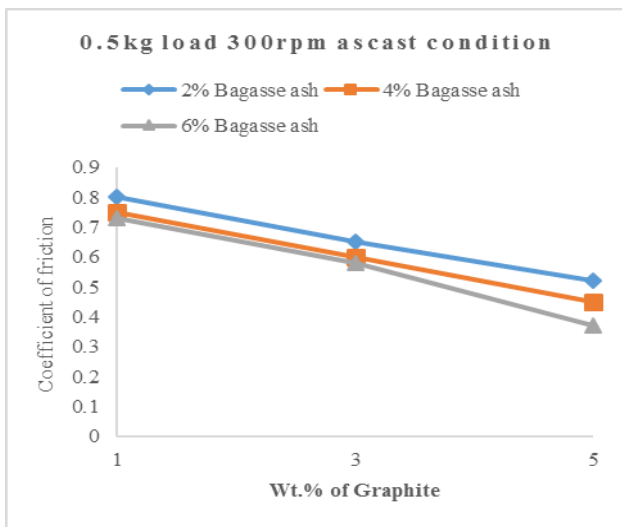


Figure 2 (b): Effect of Wt. % of reinforcement on Coefficient of Friction.

2. Effect of increasing load

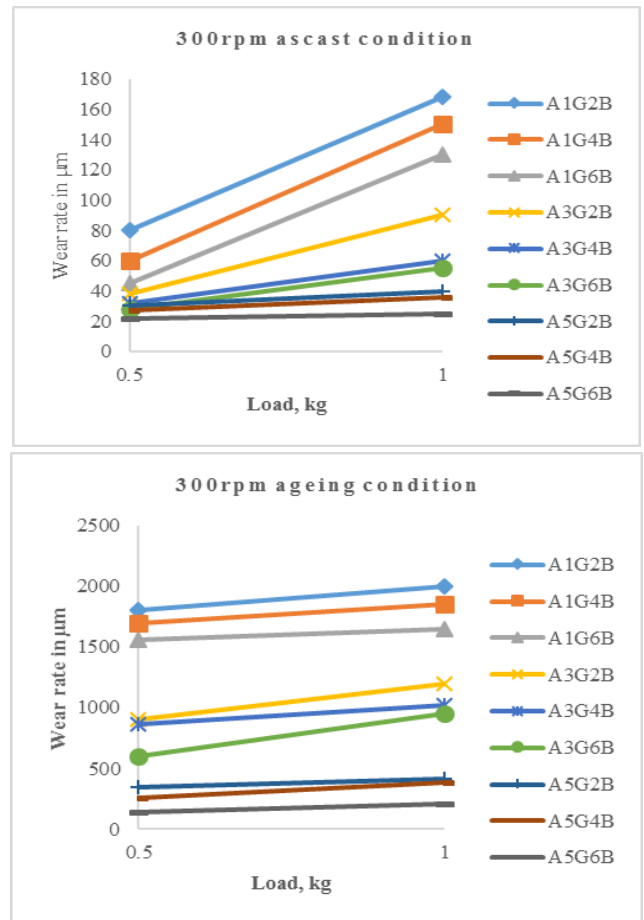
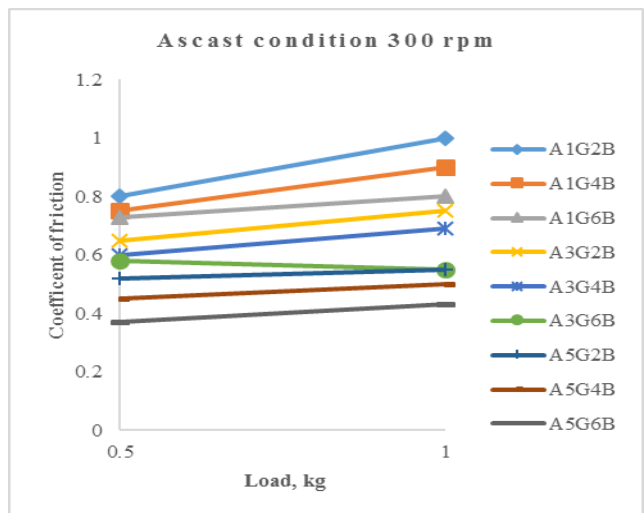


Figure 3 (a): Effect of Increasing load on Wear Rate



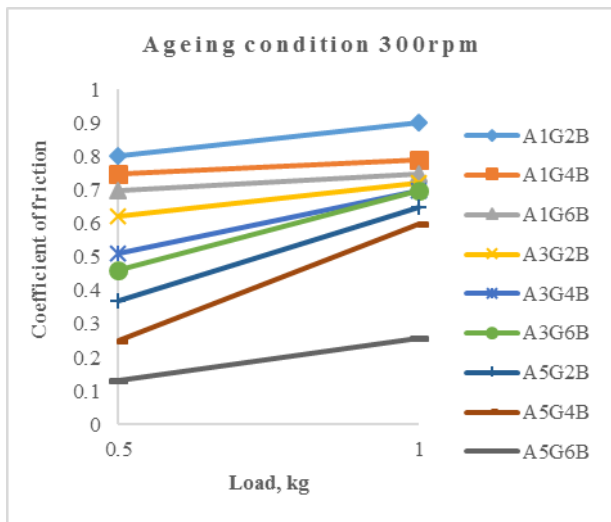


Figure 3 (b): Effect of Increasing load on Coefficient of Friction.

V. CONCLUSION

- The addition of the reinforcements has resulted in a steady decreases in wear rate and coefficient of friction.
- The wear rate reduces with increase in graphite content and it was found minimum at 5 wt. % of graphite powder, which exhibits the superior wear properties
- The effect of Graphite powder and Bagasse ash particles on the sliding wear resistance in Al 7075 alloys varies with the applied load and speed.
- Wear rate has been decreased as the ageing duration is increased. The wear resistance has been increased significantly for heat treated composites compared to as cast composites.
- Coefficient of friction is reduces as content of graphite powder increases.

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