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Study on tribological and mechanical behaviour of AA 7075 hybrid reinforced composite

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ABSTRACT

This paper deals with the influence of fly ash and aluminium oxide on the wear behaviour of Al 7075 alloy. The Al 7075 alloy reinforced with fly ash and Al₂O₃ were tested for wear resistance at three different compositions. The matrix is Al 7075 alloy and reinforcements are fly ash and Al₂O₃. The Al 7075 alloy, fly ash, and Al₂O₃ hybrid composite were prepared at 3 wt.% of Al₂O₃ for all three specimens, and 4 wt.%, 6 wt.%, 8 wt.% of fly ash. The wear test using pin on disc setup, brinell hardness test and microscopic structural analysis was conducted. From the result, the hybrid composite of sample containing 3 wt.% Al₂O₃ and 6 wt.% of fly ash is found to be the highest wear resistant material and highest mechanical resistance (tensile strength, yield stress, elongation and hardness) material among all the three samples.

Keywords: Aluminium; Hybrid metal matrix composites; Fly ash; Al₂O₃

INTRODUCTION

To present the work deals with the fabrication and testing of aluminium 7075 alloy with fly ash and Al₂O₃ reinforcement composite. The metal matrix selected was aluminium 7075 alloy and flyash and Al₂O₃ as reinforcement. Stir casting method was used to fabricate the composite metal with 4-6-8% weight of flyash contents. Al₂O₃ was taken constant at the rate of 3% for all the three samples. The wear of composite material is identified by PIN-ON-DISC setup. Aluminium 7075 is the material of high compression strength and has high bond with the addition of reinforcement. Addition of fly ash increases the wear resistance of the composite material. Hardness of hybrid composites increases with increasing Al₂O₃. Finally concluded that Aluminium 7075 alloy with flyash and ceramic particle as reinforcement will be the high wear resistance material.

LITERATURE SURVEY

Vipin k et al. (2017) [1] has investigated the fabrication and tribological testing of an aluminium fly ash composite. The metal matrix selected was aluminum and fly ash contents in different percentages were reinforced in it to fabricate the required metal matrix composite (MMC). Stir casting method was used to fabricate the MMC with 2-4-6% weight of fly ash content in aluminium. Tribological analysis of the tribo pairs formed between the smooth surfaces of the cast iron disc and smooth MMC pin has been considered and friction force and wear of the MMC were investigated by using a pin-on-disc setup. It was observed that the MMC with 6% weight of fly ash content in aluminium matrix results in less wear (0.32g) and 4% weight of fly ash content gives the low coefficient of friction (0.12) between the tribo pairs of cast iron surface and MMC surface.

K.V. Shivanandha Moorthy et al.(2017) [2] stated that multiple reinforcements TiO_2 and fly ash were utilized for the fabrication of Al7075 matrix based hybrid composites using stir casting technique followed by hot forging. In hybrid composites, the fly ash content was fixed to 3wt%. While that TiO_2 was varied from 2.5 to 10wt%. scanning electron microscope images revealed homogenous dispersion of both the reinforcements in Al7075 matrix. Compression test was conducted to study the mechanical behaviour of hybrid composites.

The hybrid composites showed increase in compressive strength with the incorporation of multiple reinforcements and further increased with the increase in weight fractions of TiO_2 particles. The thermal coefficient of hybrid composites decreased with the addition of TiO_2 and fly ash.

Baradeswaran and ElayaPerumal [3] have investigated the 7075 aluminium alloy-graphite composites for its tribological behavior under dry sliding conditions. The wear rate of Al 7075 decreases with increasing graphite content and it was minimum about 5 wt.% of graphite which possesses the superior wear properties than that of other compositions 10, 15 and 20 wt. % of graphite. Baradeswaran and Elaya Perumal [4] have investigated the effects of graphite and Al_2O_3 content in the Al 7075. The Al 7075/ Al_2O_3 /graphite hybrid composite was prepared with 5 wt. % graphite particles addition and 2, 4, 6 and 8 wt. % of Al_2O_3 the wear rate decreases with the addition of Al_2O_3 and reaches a minimum at 2 wt. % Al_2O_3 and 5 wt. % of graphite and the wear rate is about 36% less than that of the matrix material Al 7075, whereas Fig. 1 and 2 shows the wear rate of the hybrid composites retains up to certain sliding speed and load. The effect of graphite addition on friction coefficient is shown in Fig.3. The presence of graphite in the hybrid composite decreases the coefficient of friction. Moreover the hybrid composites exhibited lower coefficient of expansion and wear rate. Ravinder Kumar and Suresh Dhiman [5] have investigated the specific wear rate of the unreinforced Al 7075 alloy and hybrid aluminium metal matrix composite reinforced with 7 wt. % of SiC and 3 wt. % of graphite fabricated by using stir casting

method. Finally the Specific wear rate of alloy and hybrid composite, decrease with increase in the sliding distance for low speed (2–4 m/s) and low load (20–40 N). However, at high speed and high load specific wear rate increases with increase of sliding distance.

Suresha and Sridhar [6] have investigated the dry sliding wear behaviour of Al matrix composites reinforced with Gr and SiC particulate up to 10%. Parametric studies indicate that the wear of hybrid composites has a tendency to increase beyond % reinforcement of 7.5% and compare to the Al-Gr and Al-SiC composites, these hybrid composites exhibit better wear characteristics. Uthayakumar et al. [7] have studied the dry sliding wear behaviour of aluminium reinforced with 5% SiC and 5% B4C hybrid composite using a pin on disc tribometer. The experimental results show that the hybrid composites retain the wear resistance properties up to 60 N load and sliding speed ranges 1–4 m/s. Bijay Kumar Show et al. [8] have investigated the dry sliding wear behaviour of 6351 Al alloy and its composites with single (Al_2O_3) and hybrid ($Al_2O_3 + SiC$) reinforcements at low sliding speed (1 m s⁻¹) against a hardened EN 31 disk at different loads. At lower loads (19.6 and 29.4 N), the 6351 Al-(2 vol.% SiC + 2 vol.% Al_2O_3) hybrid composite exhibits lowest wear rate due to the presence of (SiC+ Al_2O_3) particle that resist abrasive wear to a great extent. However, at higher loads (39.2 and 63.8 N), the breakdown of (SiC+ Al_2O_3) particle clusters results in a high wear rate in the hybrid composite. Devaraju Arjun et al. [9] have investigated the wear properties of aluminium alloy 6061-T6 reinforced with hybrid composites [(SiC + Gr) and (SiC + Al_2O_3)] using friction stir processing techniques. The micro-hardness will increase due to presence of pinning effect of hard particles in SiC and Al_2O_3 . At the same time low wear rate can be exhibit in SiC and Gr particles.

Baradeswaran et al. [10] has investigated the aluminium alloy (AA) 6061 and 7075 were reinforced with 10 wt.% of boron carbide (B4C) and 5 wt.% of graphite through liquid casting technique. The high hardness and good % of elongation obtained in the AA 7075 hybrid composite compared to the AA 6061 alloy and its hybrid composite. Under this optimal

condition, the AA 7075/B4C/graphite hybrid composite exhibits higher wear resistance property compared to base alloys and AA 6061 hybrid composite.

Finally concluded that AA 7075 hybrid composite has good potential of tribological behavior. Aluminium 7075 is the material of high compression strength and has high bond with the addition of reinforcement. Addition of flyash increases the wear resistance of the composite material. Hardness of hybrid composites increases with increasing Al_2O_3 . Finally concluded that Aluminium 7075 alloy with flyash and ceramic particle as reinforcement will be the high wear resistant material.

RESULTS AND DISCUSSIONS

The Al7075 containing 3wt% of Al_2O_3 was reinforced with 4% 6% and 8% of fly ash were prepared using stir casting process About 1.0 kg of Al7075 alloy is melted in a graphite crucible heated to 850°C. When the temperature of the melt is about 30°C above the pouring temperature preheated stirrer is introduced in the melt. Agitation of the melt is started and the preheated Al_2O_3 particulates are introduced in the wt. % of 4, 6 and 8 of fly ash. The mixture was stirred at 500 rpm for 5 min by means of a spiral-shaped stirrer coupled to a motor and the temperature was kept persistent at 850°C. Due to the stirring action, the melted aluminium alloy was split into droplets owing to the shear forces brought by the impeller due to the existence of fly ash. The stirring is

continued to ensure a proper mixing. The slurry of the composites thus prepared was poured into the pre- heated steel moulds. The composite specimens were tested for hardness, tensile strength, compressive strength, and wear resistance.

Wear Test

A pin on disc test apparatus shown was used to investigate the dry sliding wear behavior of Al 7075/ Al_2O_3 / fly ash hybrid composites. A pin specimen of 150 mm diameter and 500 mm height for wear test was prepared from the above composites. An OHNS (Oil Hardened Nickel Steel) 150 mm diameter steel disc of 60HRc was used as the counter surface in the wear test. The test was conducted at the load of 1kg at a sliding speed of 40 + / - 1 rpm for 84 times. The test was conducted at room temperature (30°C) and relative humidity of 60–65%. The initial weight of the specimen was measured in an electronic weighing machine with a least count of 0.0001 g. A strain gauged friction detecting arm holds and loads the pin specimen vertically on a rotating hardened steel disc. The frictional traction encountered by the pin during sliding is measured continuously by a PC-based data- logging system for analysis. The wear test was conducted after the initial run in period when the pin specimens were entirely in contact with the disc surface. In each test after running the fixed sliding distance the specimen was removed, cleaned with acetone, dried and weighed to determine the weight loss due to wear. The wear rates were determined using the weight loss method

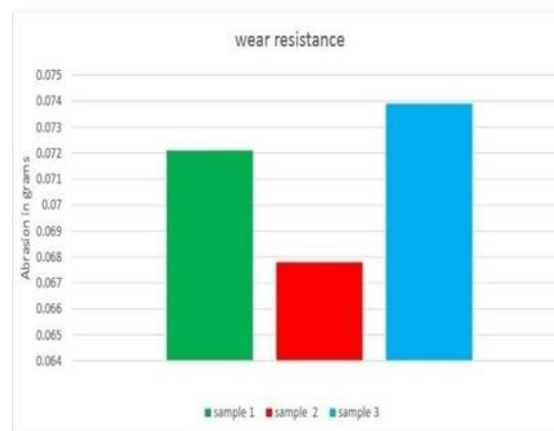


Fig. 1 Wear Test Chart

Tensile Test

As per the ASTM E08-16a Standard, the tensile strength was evaluated on the cylindrical rod of casted composites. The 1200 grit grinding SiC paper used to polish the test specimens in order to decrease the machining scratches and the effects of

surface defects on the sample. The universal testing machine loaded with 10 KN load cell was used to conduct the tensile test. The tensile strength was evaluated at cross head speed of 2.5 mm/min.

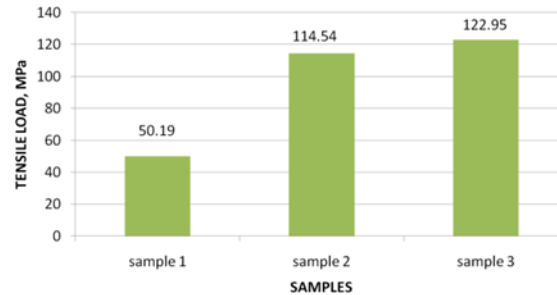


Fig. 2 Tensile Test Chart

Yield Stress

Yield stress was performed on these samples with computerized Universal Testing Machine at room temperature and yield stress of these samples was measured as per ASTM E8-16a standards .since it was computerized machine the yield stress was recorded accurately. The yield stress of

sample 1 is measured as 100.5Mpa and the yield stress of sample 2 is measured as 100.72MPa and the yield stress of sample 3 is measured as 110.07MPa.The yield stress of sample 3 is 110.07MPa and it's higher when compared to other two samples

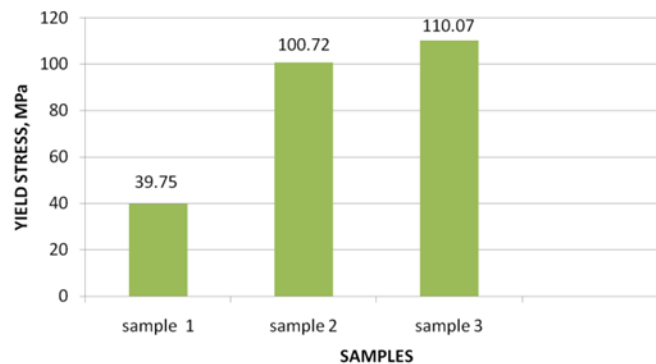


Fig. 3 Yield Test Chart

Elongation Test

Elongation test was performed on this samples with the computerized Universal Testing Machine at room temperature and elongation of these samples was measured as per ASTM E8-16a standards. Since it was computerized machine elongation was recorded accurately. The elongation of sample 1 is measured as 5.16% and the elongation of sample 2 is measured as 4.58%

and the elongation of sample 3 is measured as 5.56%.The elongation of sample 3 is 5.56% and it's higher when compared to other two samples.

The hardness tests were carried out according to ASTM E10-15 standards using Brinell hardness testing machine with a 5 mm ball indenter and 250 kg load for 30 s. The test was conducted at room temperature and the Measurement of hardness was taken at five different places on each sample to obtain an average value of hardness.

HARDNESS TES

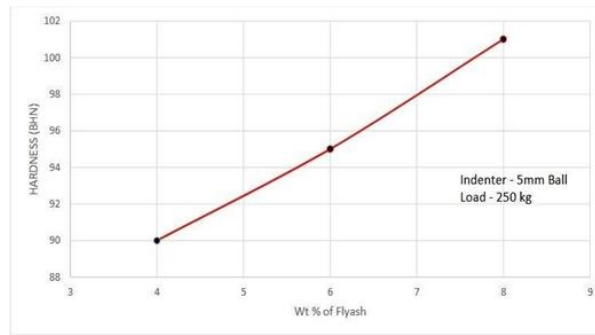
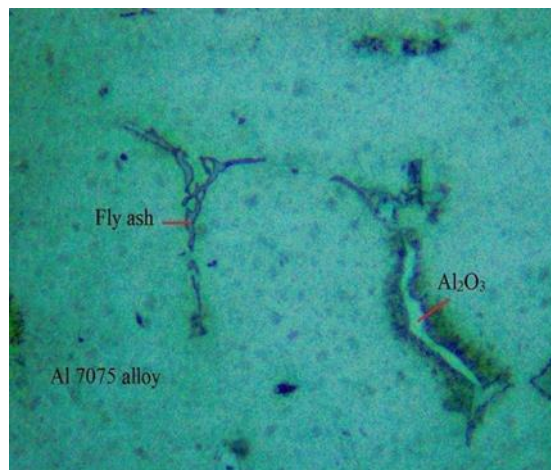
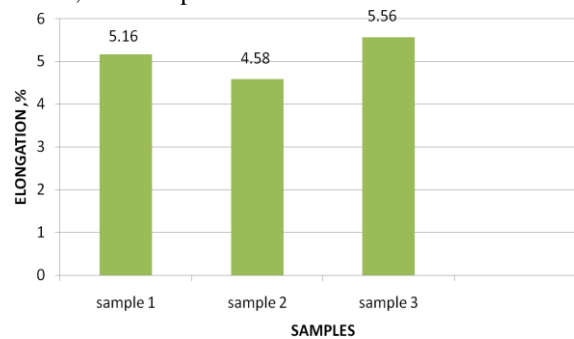


Fig. 4 Hardness Test Chart

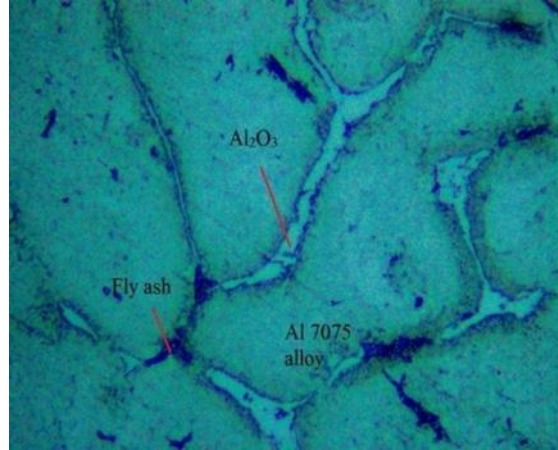
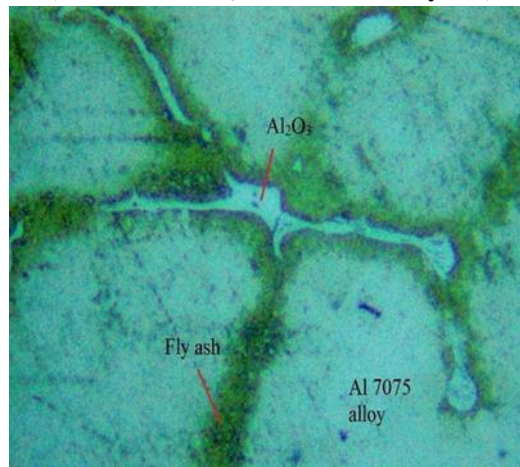
Microscopic View

In below the figure revealed that aluminum alloy 7075 reinforced with various content of the reinforced materials. Various percentages of the composite materials could be polished by using an emery sheet. There are various type emery sheet will be used for polishing the materials like 120, 400, 800, 1200, 1500 and 2500 grade size sheet. After completion of polishing process, the sample

goes too etched for viewing the micro-structure image analysis. The test would be conducted on our college. In the test results of composition has been showed in the figure. The reinforcing particles were dispersed in the composite materials. Those particles were clearly visible in metallurgical microscope image analysis. Initially Aluminium alloy 7075 reinforced with 4, 6 and 8 wt. % of fly ash and 3 wt % Al_2O_3



SAMPLE-1
(3 wt.% of Al_2O_3 and 4 wt.% of fly ash)

**SAMPLE-2****(3 wt.% of Al₂O₃ and 6 wt.% of fly ash)****SAMPLE-3****(3 wt.% of Al₂O₃ and 8 wt.% of fly ash)**

CONCLUSION

Al 7075 alloy fly ash and Al₂O₃ composite were prepared by using stir casting process with different wt. % (4, 6, 8) of reinforcements particles. From the result sample 2 is found to be the highest wear resisting material when compared to other two samples. The wear of sample 2 is 0.0678 gm. Its composition is Al 7075 alloy of 910 gm, fly ash of 60 gm, Al₂O₃ of 30 gm. Hence it can be concluded that the addition of Al₂O₃ +

fly ash to the base alloy of Al7075 alloy improves the wear behavior of the composite materials. The microstructure of the composite indicates the distribution of the fly ash components throughout the aluminium matrix. The sample 1 is found to be the highest compressive material compare to other samples. Sample 3 is found to be the highest tensile, elongation & yield stress value when compared to other two samples. The tensile value of sample 3 is 122.95 MPa.

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