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Experimental Investigation of Mechanical Properties on Al7075 with Hybrid Reinforcements

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Abstract: *The study's main objective is to investigate the dry sliding wear and other mechanical properties of aluminium with newer dual particle reinforced hybrid composite compositions. The stir casting method was used to create the aluminium hybrid metal matrix composite, which was then tested to determine its hardness, wear and microscopic photographs of worn-out surfaces as a result of the wear test. Three alternative reinforcing ratios Sample 1 (1% B_4C and 3% SiC), Sample 2 (1% B_4C and 6% SiC), and Sample 3 (1% B_4C and 9% SiC) were used to manufacture hybrid composites. In this study, samples made with three different ratios of reinforced composite material were tested for hardness and temperature wear. Results illustrated that sample 2's hardness and wear attributes (1% B_4C and 6% SiC) are superior to those of the other samples in terms of both hardness and wear rate.*

Keywords: Reinforced hybrid composite, Stir casting, dry sliding wear test, Hardness test

I. INTRODUCTION

Hybrid Metal matrix composites are utilized for a range of applications, including the automotive industry and the aviation sector. They have a greater specific modulus, improved strength, and better anti-corrosive qualities because of their hardness. Aluminum-composite materials are well known for their distinctive comprehensive capabilities, such as mechanical and tribiological qualities. Aluminium 7075 exhibits high corrosive property due to the combination of Zn + Mg + Cu + Fe + Mn + Si + Ti + Cr. Aluminum-based metal matrix composites (MMCs) are utilized in modules for marine buildings, boats, vehicle parts, combat components, and many more uses. Concerns still exist about the poor strength and low melting point. MMCs considerably outperform unreinforced alloys in terms of properties including high specific strength, tailored module, damping capacity, and strong wear resistance. Low-density composites with affordable reinforcements seem to be becoming more and more common. When compared to alloys from the (Al6XXX) series, Al7075 has a high corrosion rate but is lightweight and simple to handle. Metal matrix composites are made up of many materials that consistently blend together, usually metal and ceramic.

II. LITERATURE SURVEY

Reginald Umunakweet al studied that the production and characterization of metal matrix composites reinforced with fly ash is a very active research area. This paper presents a review on the properties of hybrid aluminum–SiC/fly ash, hybrid aluminum–B4C/fly ash, hybrid aluminum–Al2O3/fly ash, hybrid aluminum–graphite/fly ash and hybrid aluminum–BN/fly ash composites. The major production route utilized by the various authors was stir casting technique and its variant; powder metallurgy was also utilized by few authors. Improved mechanical properties were observed in the hybrid composites, compared to the composites filled with single reinforcements. It was observed that the properties of the composites were influenced by both the volume fractions of the reinforcements in the matrix and the percentage of replacement of the ceramic reinforcements with fly ash in the hybrid reinforcement mixture. In most of the reports, beyond 40 wt% of replacement of ceramic reinforcements

By fly ash, the wear resistance, strength and ductility of the hybrid composites excessively reduced (high brittle tendency), while corrosion tendency increased. Generally, the mechanical properties and wear resistance of the hybrid composites were reported to increase with increase in weight fractions of the reinforcement in the composites until about 15 wt%, beyond which the properties depreciate. At the right ratio of the reinforcements in the hybrid mixture and up to about 15 wt% weight fractions of reinforcements in the composites, the reinforcements were reported to distribute uniformly in the matrix.

Siva Sankararajuet al studied that the composite hardness and tensile strength is increased with increasing % of CSA. Similarly, density and elongation decreased. The Grey–Fuzzy Reasoning Grade (GFRG) used for optimization of response with decrease the uncertainty in decision making. The tribological performances of characteristics are improved using grey-fuzzy relation. Analysis of variance (ANOVA) of GFRG results specify load is the most influencing parameter followed by percentage of CSA, sliding velocity and sliding distance. The initial parameter of the DFA, GRG and GRFG is 0.348, 0.736 and 0.816 through optimal conditional values of the dfa, grg and gfrg are 0.854, 0.806 and 0.864 respectively. So, it states that GFRG in wear behavioral parameters of csap composites has greater improve by using Grey-Fuzzy Reasoning Approach (GFRA). The achieved optimal condition is l1r2d2v2 (i.e. Load (10n), % of CSA (15), sliding distance (2000m) and velocity (2m/s). Finally, confirmation test is conducted to validate the regression equation and the worn-out surface is examined by Scanning Electron Microscopic (SEM).

P.B.Ashaet al studied that thedevelopment of lightweight aluminium-based composite (AlC) and to examine the influence of reinforcement on mechanical, physical & wear properties of AlC reinforced with Boron Carbide (B4C) is the main purpose of the current research. The produced AlC is of great significance because they display superior mechanical properties and better resistance to wear compared with the base traditional material (matrix 6061Al). The denouement of the experimental investigation discovered that the proposed composite with 8% of total B4C reinforcement material displays high hardness, high yield strength, relatively low density, and low specific wear rate. The equitable distribution of particles was also analyzed using SEM evaluation, with the findings indicating the consistent dissemination of ceramic B4C reinforcement particles in the base matrix alloy.

K.SooryaPrakashet al studied that the titanium alloys are used in aerospace and automotive applications because of its high specific strength, stiffness and good machinability but its wear resistance is inadequate. To eliminate this property lag Boron Carbide (B_4C) ceramic particles are reinforced with Ti-6Al-4V through powder metallurgy route (PM). Reinforcement particles are mixed with base alloy for the weight percentage of 0, 5 and 10 so as to analyze the effect of reinforcements on mechanical, corrosion and wear properties. This research outcome corresponds to decreased density, increased hardness and corrosion resistance capability for significant increase in B_4C content of the newer composite developed and tested. Applied load signify higher effect on wear performance of the composite specimens followed by B_4C addition percentage. Scanning Electron Microscope results reveal that B_4C reinforced Ti-6Al-4V composite comprise for higher wear resistance and illustrate mild worn surface when compared to that of unreinforced Ti alloy.

III. MATERIALS

AL7075 :

Al7075, the main alloying component of which is zinc. It has great ductility, high strength, toughness, and fatigue resistance, among other outstanding mechanical qualities. Due to micro segregation, it is more prone to embrittlement than other aluminium alloys, but it has far greater corrosion resistance than alloys from the 2000 family. It is one of the alloys of aluminium that is most frequently employed in high-stress structural applications, and it is frequently utilized in structural components for aircraft.

B_4C:

Boron Carbide (B_4C) can be used as a neutron absorber in nuclear power reactors since it can withstand neutrons without producing long-lived radionuclides. In nuclear applications, such as the covering, control rod, and shut-down pellets, boron carbide is used. To increase surface area, boron carbide is utilized to sprinkle inside control rods. The third hardest material after spherical beryllium nitride and diamonds is known as boron carbide. The density of B_4C is 2.52 g/cm3. A recently formed alloy loses density due to its mechanical properties, increasing the strength-to-weight ratio and lowering density.

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SiC:

Silicon Carbide (SiC) is much harder than metals made of aluminium. SiC has an advantage over other reinforcement materials, such as its thermal conductivity, strength, and corrosion resistance, and its density, which is 3.2 g/cm3, is comparable to that of aluminium. In decreasing conditions, it offers great resistance to chemical assaults and erosion. By adding SiC reinforcement, aluminium alloys' hardness and wear resistance can be increased.

IV. METHODOLOGY

The chemical Composition the specimen is given below:

Elements	Zn	Mg	Cu	Cr	Si	Fe	Ti	Others	Al
Composition %	5.2	2.1	1.5	0.18	0.12	0.15	0.06	0.15	90.4

Table 1 showing composition of Al7075

Development of composites: In this study, stir casting was utilized to create composite materials using commercial-grade aluminium Al7075 as the matrix material and boron carbide and silicon carbide as the reinforcement materials. Using weighing equipment, each constituent is individually measured to get the required composition. In a crucible, the measured mixture is added and thoroughly spun. The aluminium base materials are heated in the furnace to 680 °C then stirring is carried out following stirring is carried out alternately for every 30 minutes with a frequency of 20 to 25 kHz, and the resulting composite is cast in the shape of three 30 mm diameter and 300 mm long rods.

Sample preparation: We calculated the different compositions by integrating reinforcement using the basic composite material from the early experiment. And that is a summary of the data. A freshly created alloy's total weight had been determined using 1%,3%,6%,9% of the total weight as reinforcing. The below table will show the composition in a more clear manner.

Sample no	Al7075 (wt%)	B4C (wt%)	SiC (wt%)
1	96	1	3
2	93	1	6
3	90	1	9

Table 2 showing composition of casted rods.

Wear test: Using a pin-on-disc test setup, the wear behaviour of Al7075/ B_4C/ SiC was examined. From the aforementioned composites, specimens for wear testing with dimensions of 20 mm in height and 6 mm in diameter were machined and metallographically polished.

Hardness test: Vickers hardness testers quantify a material's hardness as a resistance to distortion or penetration through abrasion and scrape. Hardness results from how durable solid substance changes into various permanent forms when compressive force is applied.

V. RESULT AND DISCUSSION

Hardness test: A Vickers hardness testing equipment was used to evaluate hardness using a load of 500g and a diamond indenter with a 13.6 degree angle. At least three different locations were taken into consideration for determining the hardness value of the samples.We can see that sample 2 has a harder surface, with a hardness of around 153 HV0.5. Causing us to get the conclusion that sample 2 is harder than the other two samples.

VICKERS HARDNESS TEST RESULTS	
SAMPLE 1	140 HV1 (136, 145, 138)
SAMPLE 2	153 HV1 (151, 153, 155)
SAMPLE 3	122 HV1 (119, 126, 120)

Table 3 showing hardness test results

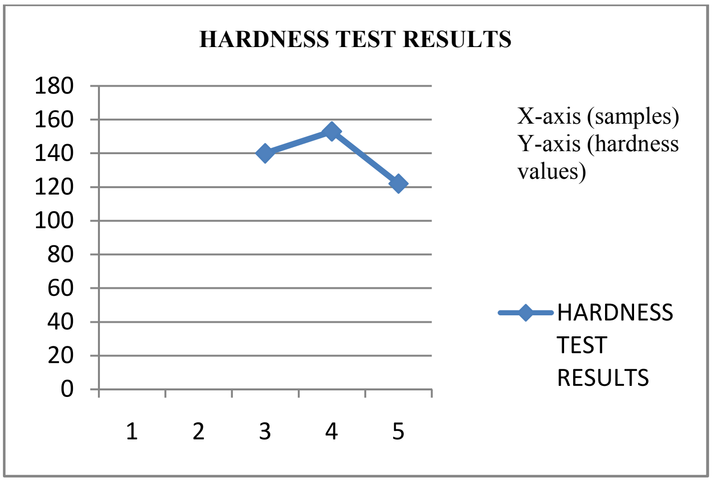

Figure1 Graph showing hardness test results

Dry sliding wear test: The wear tests are carried out with a pin-on-a-disc apparatus under conditions of relative humidity of 50%, room temperature was maintained, a weight of 30 N, a 1000-meter sliding distance, and sliding speeds of 300 rpm and 0.63 m/s, respectively. Al7075 + 1%B_4C + 6%SiC Sample 2 had a lower wear rate compared to the other samples. This allows us to draw the conclusion that sample 2 has the superior wear data.

DRY SLIDING WEAR TEST RESULTS	
SAMPLE 1	223 microns
SAMPLE 2	210 microns
SAMPLE 3	246 microns

Table 4 showing wear test results

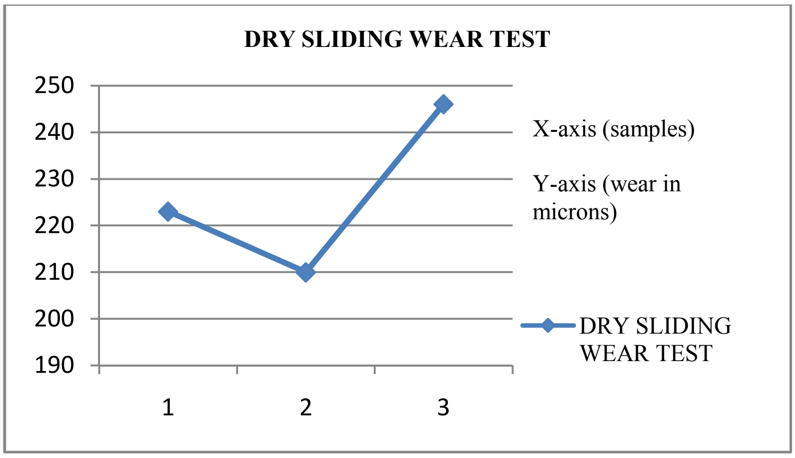

Figure 2 Graph showing wear test results

Microstructure analysis: A video microscope was used to capture the micro structural images. And the pictures make it evident where the three samples' worn-out portions are. These photos had a resolution of roughly 100 micro meters. In sample 2, the delaminations and rough lines of areas were least noticeable. The outcomes of the other two tests are also supported by the images.

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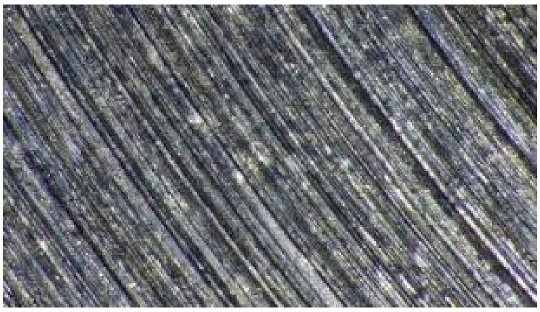

Figure3 showing microstructure of S_1

Figure 4 showing microstructure of S_2

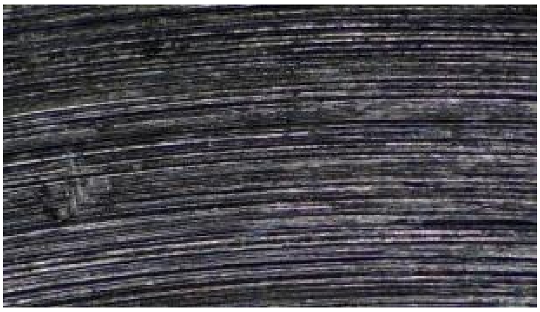

Figure 5 showing microstructure of S_3

VI. CONCLUSION

Stir casting is used to create a newly created Al7075-B_4C-SiC composite with a changeable reinforcing weight percentage. The following results could come from research on the microstructure and characteristics of composites.

The sample 2 with the highest hardness of around 153 HV1 and the lowest temperature wear rate of about 210 microns, according to the results of all three samples.

The sample specimens that underwent temperature wear testing can be seen in microscopic photographs to have spots that are worn out and delaminated.

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