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Wear Analysis and Experimentation of Sintered Al-SiCp and Al-B_4Cp Composites with Deformation Predictions

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Abstract

Complex geometries and porous components are very difficult to manufacture using traditional methods. Powder metallurgy is a metal forming process that allows complex shapes to be easily formed without loss of material. Metal matrix composites are used for high thermal conductivity and high wear resistance. In Al-B4CP, the composition of boron carbide is changed by 5%, 10%, 15%, and 20%. Al-SiCp composites maintain similar weight fractions. The blended mixture is compacted and sintered to the required standard sample size. After heat treatment, samples are tested for wear rate using a pin-on-disc wear tester, which is analyzed with analysis software.

Keywords: *Powder metallurgy, Sintering, Pin-on-disc-machine, Wear*

1.0 Introduction

Wear refers to the removal and deformation of material on one surface as a result of interaction between the surfaces, especially mechanical action on the opposite surface. Wear tests are performed to predict wear performance and study wear mechanisms. A material's wear characteristics that determine if the material is suitable for a particular wear application. Wear testing is used to study the effects of treatment conditions on wear performance so that the potential for using specific surface technologies to reduce wear for specific applications and optimized surface treatment conditions can be achieved. It will be executed. Metal matrix composite MMCs can be developed in a variety of ways. Based on the type, size and morphology of reinforcement, MMC is manufactured by various methods such as stir casting, squeeze casting, spray deposition, liquid infiltration and powder metallurgy.

Aluminum Matrix Composites (AMC) have recently gained traction for structural applications in the aerospace, automotive, construction, packaging, electronics, and military industries. Besides iron and steel, aluminum alloys are the most commonly used metallic materials. It is especially used in the production of automotive parts such as cylinder liners,

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pistons, drive shafts, brake discs, cylinder heads, cylinder blocks, intake manifolds, rear axles and differential cases. Their high strength-to-weight ratio, high thermal conductivity, and specific stiffness have increased researchers' interest in further improving the material's properties to make it suitable for all applications. Aluminum accounts for approximately 8% of the curb weight of today's cars, trucks and minivans. However, an inadequate wear resistance and low seizure loads prevent a direct use of aluminium alloys in automotive parts due to the intensive friction, high thermal and mechanical loading. According to Atrian et al. the combination of these reinforced particles in the metal matrix composite increases the foot bracket's strength, stiffness, and hardness, causing it to function as a fracture shield. This ongoing problem is addressed by the current work, which uses ANSYS software to determine the maximum holding stress and minimal displacements of chosen Al6061-T6 and Al7075-T6 Hybrid Metal Matrix Composites (HMMC). According to Ravi et al., SiC particulate increases the yield strength of the aluminium alloys 6061 and 7075. In particular, it has been demonstrated that when reinforcing particles are added to Al 6061 cross-links, the tensile stress and impact values of Al 6061 increase compared to Al 7075 cross-links. 2019 studied the mechanical properties of alloys Al 6061 and Al 7075. Bejaxhin et al findings [24] about the impact of various coatings on the electrodes used in the EDM process to reduce surface roughness have been experimentally confirmed. Ti, Al, and Cr particle deposition in PVD coatings, which has a greater influence on surface roughness, has led to the outstanding surface roughness.

Modeling is therefore used to predict induced deflection in thin-walled 6061 aluminum alloy and experimentally measured using a horizontal milling machine. The position of the support head of the milling fixture is predicted based on simulation performance and tested experimentally. Surface roughness was measured both before and after using the milling equipment.

Ceramic particles such as Al_2O_3 and SiC are the most commonly used materials to strengthen aluminum. Boron carbide (B4C) is a potential alternative to SiC and Al_2O_3 (He is the third hardest material after diamond and boron nitride) due to its high hardness. Boron carbide has attractive properties such as high strength, low density (2.52 g/cm^3), very high hardness, good wear resistance and good chemical stability. There is growing interest in low density composites. Proposed applications for Al-B4C composites include use as structural neutron absorbers, armor plate materials, and substrate materials for computer hard drives. Lee et al. He studied the effects of reinforcement types on the tensile properties of Al-B4C and Al-SiC composites, and found that the strength of Al-B4C composites was greater than that of Al-SiC composites. Metal matrix composites of aluminum and boron carbide are manufactured using powder metallurgy techniques. The manufactured Al-B4C-MMC is tested for wear resistance with a pin-on-disk abrasion tester. An attempt was made to compare the experimental results with the graphical results of the analysis software ANSYS. Both wear rates and simulation results for specific composites made of AlSiC and AlB4Cp reinforced composites are compared and can reveal application-related uses.

2.0 Materials and Methods

6061 aluminum powder (Al-6061) and boron carbide powder (B4Cp) with average sizes of 120 μm and 30 μm respectively were selected for the metal matrix composite. Al and B4Cp powder is mixed with different components of B4Cp powder such as B4Cp powder 5, 10, 15 and 20% by weight. The powder is mixed evenly during the ball grinding process.

Table 1: Weight percentages of Aluminium Boroncarbide (Al-B4C)

Aluminium	Boron carbide
95%	5%
90%	10%
85%	15%
80%	20%

3.0 Sample Preparation

The equivalent amount of metal powder is taken by weight. For sample sizes of 10 mm diameter and 30 mm height. Weighing is performed in a very precise balance with three-digit decimal accuracy prepared for each sample.

4.0 Blending

Composites are similarly made up of two or more different components, but they are devoid of metals. A mixture might be homogeneous or heterogeneous and be an alloy. A composite is always a blend of different materials. It is the process of mixing dough by hand or other mixers. Al-B4Cp powder was mechanically mixed for 2 hrs. It will be compacted with enough reinforcement.

5.0 Compacting

The purpose of compaction is to force the powder into the desired shape and as close to the final dimensions as possible. Designed to impart the desired degree and type of

Figure 1: Heat treatment in Muffle furnace for Specimen preparation

porosity and provide sufficient strength for curing. Compression was performed on the UTM (Universal Testing Machine). Compression pressure was 50 kN for 2 minutes at room temperature.

6.0 Sintering

The compacts were sintered in an electric muffle furnace by gradually increasing the temperature to 570°C. and the samples were maintained at this temperature and decreased in 100°C. increments as shown in Fig.1. The compact was removed from the oven and allowed to cool.

7.0 Experimental Procedure

Wear Test

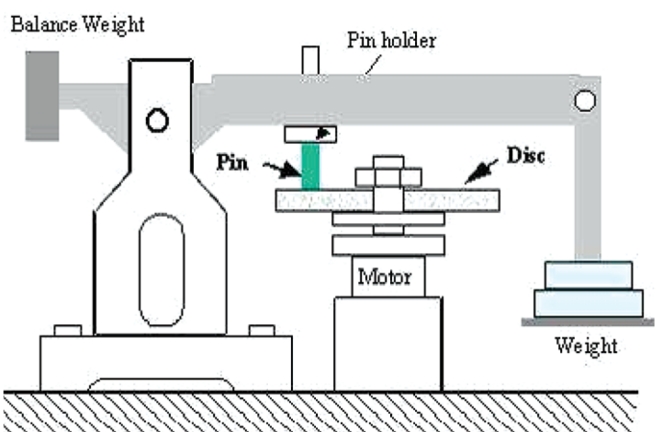

Figure 2: Pin-on-Disc-machine arrangement for wear test

Dry sliding wear tests were performed in air at room temperature using a pin-on-disc machine. During the experiment, slippage between the pin and disc can wear both contact surfaces. A sample size of 10×30 mm was prepared. The wear test was performed with a load of 10 N and a sliding speed of 1.5 m/s. Weight loss of the pins was measured under all loading conditions. Weight loss data were converted to volume loss data using the density of aluminum. In a pin-to-disk abrasion tester, as shown in Figure 2, a pin is pressed against a rotating flat disk specimen, exhibiting a circular wear path through the machine.

8.0 Results and Discussion

Dry sliding wear tests were performed on various compositions of Al-B4C composites under constant speed and load conditions. Wear rate was calculated by weighing the samples before and after testing. The Figure 1 shows the change in wear rate when the composition of Al-B4C is changed. Graphs show changes in frictional force, coefficient of friction, and wear rate over time.

From the graph in Figure 4 above, it can be seen that this wear rate decreases with increasing B4C composition and the wear rate increases with time. As the B4C composition increased, the coefficient of friction also decreased. The results obtained from the experimental method have been compared to the analysis software outcomes of ANSYS. The load conditions are applied and the results are calculated. Understanding friction, friction force, and kind of friction is necessary in order to comprehend the idea of coefficient of friction. A surface is said to be frictional if it prevents relative motion between two surfaces that are in touch, such as when they are resting, sliding, or rolling.

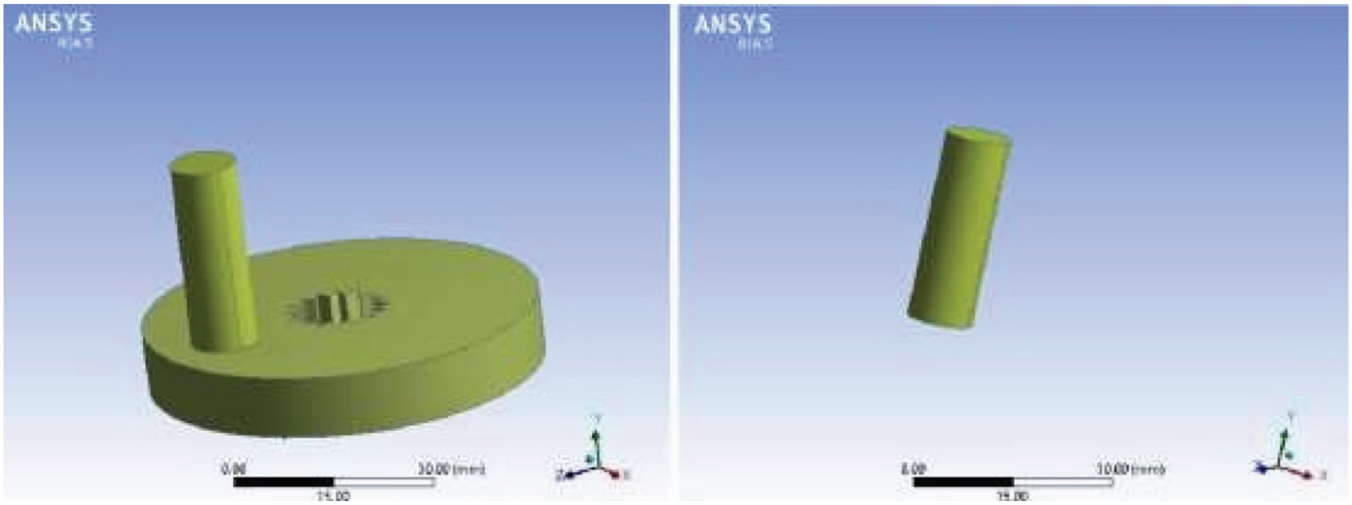

Figure 3: ANSYS simulation results of Pinon Discapparatus setup and Pin modelling

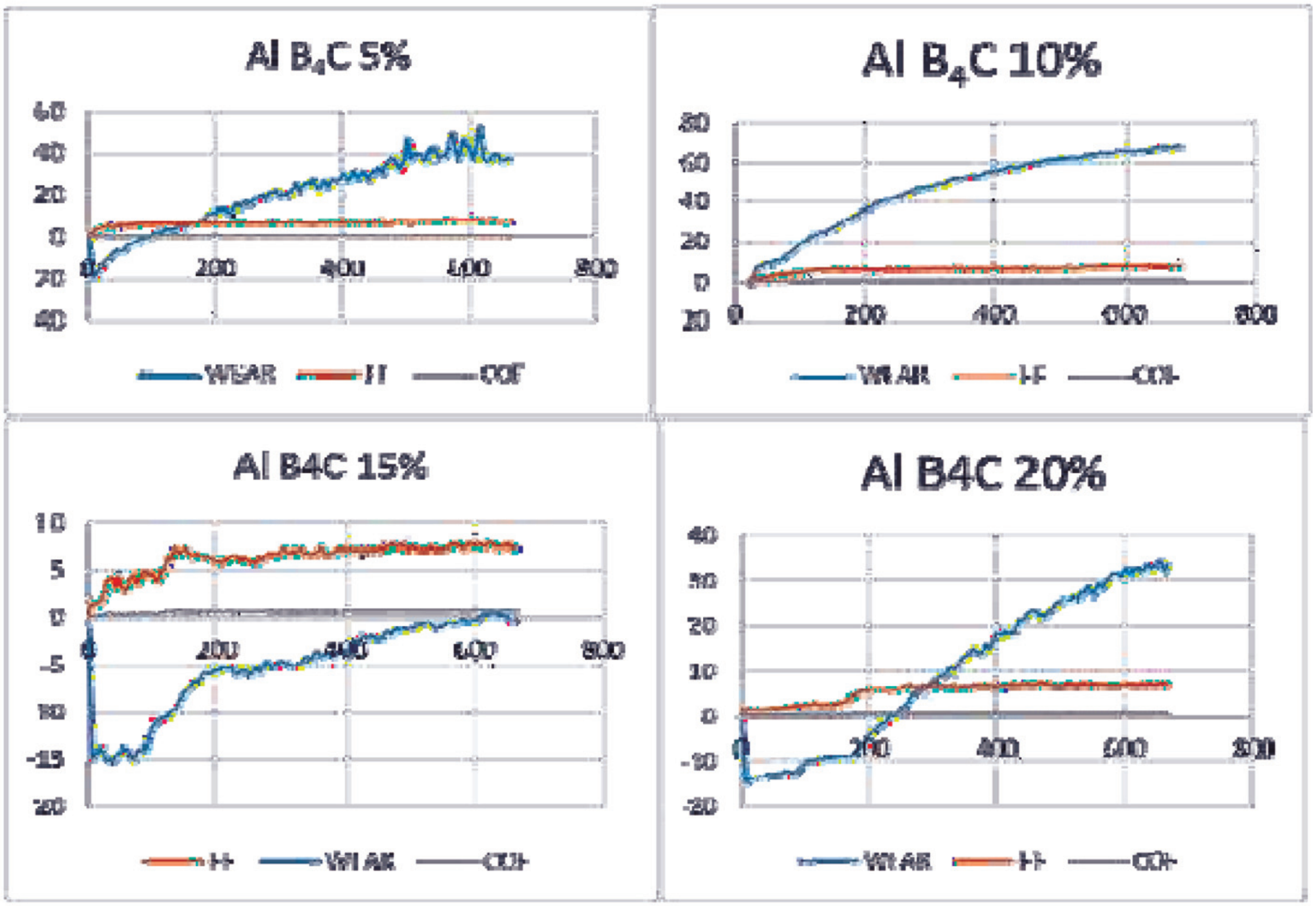

Figure 4: Frictional force, Coefficient of friction, and Wear rate with respect to time for the composites of (a) 5%Al-B_4C, (b) 10%Al-B_4C, (c) 15% Al-B_4C, (d) 20% Al-B_4C

Friction frequently results from rough surfaces. It implies that friction will result from the relative motion between two surfaces if they are not intended for motion. Friction is always closely connected with surface roughness. Friction is greater on surfaces that are rougher. Friction will be reduced on smoother surfaces over rough ones. Thus the coefficient of friction describes the degree of interaction between two surfaces when there is friction. The value of the coefficient of friction can be used to calculate surface roughness. When the usual force exerted on an item causes friction, that thing is under observation. Both the wear and friction factor is relatively smooth and regular in Figure 4. Especially, in the Figure 4(a) and (c) the uniform wear rate have produced due to the 10% and 20% of added reinforcement with the Aluminium alloy components. There are no fluctuations have been identified from the curves. But the instantaneous curves were occurred during the wear testing of specimen having 5% and 15% of reinforcements with the Al alloys. The increase of brittle nature reinforcements can improve its rigidity as well as it will increase its brittle property. So it is possible to occur any fracture or cracks. Even though the material was confirmed from the simulation predictive outputs using deformation related software.

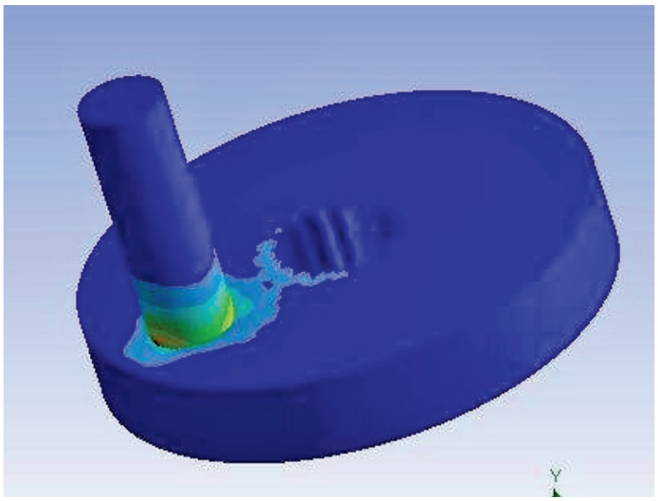

Figure 5: Deformation results of Pin on Discfunction

9.0 Conclusion

Aluminum alloy composites with varying amounts of boron carbide particles were successfully fabricated by powder metallurgy process. A uniform distribution of boron carbide particles in the matrix phase was obtained. The hardness of the composites improved and the density decreased with increasing amount of boron carbide in the matrix phase. Increasing the amount of boron carbide particles in the composite decreased the wear rate of the Al-B4C composite. Therefore, increasing his B4C composition of the composite is a better way to increase the wear resistance of aluminum alloys.

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