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Aluminium 6061/Sic/Graphene Composite Studies for Industry Application

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Abstract:

The composites were made using powder metallurgy and different proportions of graphene and SiC particles. On the samples, measurements of hardness were also taken..The hardness result demonstrates that as the weight % of SiC/ graphene particles enhance' hardness of samples.The objective of this scientific study is to examine the wear and friction behavior of hybrid composites treated with Al 6061 alloy and reinforced with graphite particles throughout a range of time periods.

Keywords: Wear loss, Hardness, Time, Composite.

In order to meet customer needs, more affordable and dependable engineering materials are in high demand as technology advances quickly in the engineering business. The aluminum 6061 alloy shows promise in the structural and functional domains due to its moderate strength to weight ratio, superior corrosion resistance, acceptable mechanical characteristics, and simplicity in heat treatment.. These days, a lot of researchers employ metal matrix composites to balance the corrosion, tribological, and mechanical behaviour of aluminium 6061 alloys under particular environmental circumstances. Higher engineering qualities inside the composites were made possible by the single, double, and hybrid reinforcements [1-3]. Depending on the type of reinforcement used, composites can reduce weight by 15–40% in addition to possessing other desirable qualities for applications of mechanical properties [4]. Although ductile metal alloys are the chosen matrix material, hard ceramic materials are used as reinforcing particles.

A second phase in metal matrix composites (MMCs) acts as reinforcement for the metal matrix. Two typical forms of reinforcing phases are ceramic particles and fibres composed of various materials, including carbon, ceramics, and other metals. Copper, magnesium, titanium, and aluminium (Al, Mg) (Cu) among others that are accessible. Because of its exceptional properties—such as its low melting point, superior toughness, strong strength-to-weight ratio, and affordability aluminium is one of the preferred matrix material currently available [5]. Due to its favorable properties, aluminium is used more often than other matrices in the fabrication of composite materials. These properties can be modified by carefully considering the matrix, reinforcements, and processing methods [6-10]. The automotive, aerospace, and defense industries commonly employ AMCs, a form of lightweight material, because of their many mechanical features.

SiC is a commonly utilized ceramic particle within the carbide nature category..It exhibits remarkable resistance against thermal shock and damage. At high temperatures, its mechanical behaviour is satisfactory. SiC is widely used in mechanical seals because of its resilience to chemicals and wear. SiC is a chemically manufactured material that is notable for its extraordinarily excellent resistance to abrasion and toughness. Compressor seals, valve parts, and wear-intensive components like wheels and retainer for the printing industry are among their frequently used applications.. Several researchers have examined how the uniform dispersion of SiC microns or nanoparticles in the aluminium matrix enhances the mechanical, physical, and interfacial characteristics [11-13]. The outstanding qualities of graphene, including its high mechanical strength and modulus, electrical and thermal conductivity, and optical transmittance, have garnered significant interest in recent years. Graphene a hexagonal lattice of carbon atoms arranged in two dimensions is the basic constituent of various allotropic forms of carbon, including graphite, fullerenes, diamonds, and carbon nanotubes [14-16]. The thinnest substance is called graphene, which is composed of only one layer of carbon atoms joined by an overlapping sp^2 hybrid bond as the backbone. The unusual features of graphene originate from the 2p orbitals, which created sheet of carbons that forms graphene.

There are several methods for preparing Al-matrix composites, including fraction powder metallurgy, stir casting, and mechanical alloying [17-19]. Because of the uniform distribution and refinement of reinforcement particles between Al matrix grains, mechanical milling is a crucial approach to manufacture AMCs with critical mechanical properties .This process is dependent on a number of factors, including the kind of mill, length of time, mass ratio of the ball to powder, machine speed, and process medium. In this work, powdered Al/SiC/graphene nanocomposite with varying graphene percentages are created by powder metallurgy method.

2. Experimental Procedure:

SiC and graphene incorporated in different weight percentages using AA 6061 via ball milling process. The powder metallurgy method was used to process Sample 1 (AA 6061), Sample 2 (2.5 wt% SiC and 2 wt% Graphene), and Sample 3 (3.5 wt% SiC 3.wt% Graphene). The different weight percentages of AA6061/SiC/Graphene Hybrid Composites were obtained as a 1.5 cm diameter and 3 cm length rod. AA6061 is a matrix alloy supplemented with varying proportions of graphene and SiC. Throughout the experiment, the reinforcement particles were supplied gradually to provide a homogeneous distribution. The mixes were compressed at 400 MPa and sintered for an hour at 200 °C. Finally, by extruding the composite materials through a hydraulic extrusion mold that had been preheated, at the same temperature, the materials took the shape of metal blocks. Heat treatment was done to the composite materials after extrusion. After dissolving the composite materials for an hour at 500°C, they were quickly cooled in water. Following chilling, the samples are heated at a rate of 10°C per minute for eight hours, to a temperature of 180°C.

3. Result and Discussions

The EDS spectra of pure AA 6061aluminum and graphene-based AA 6061aluminum samples are displayed in Fig1.Sample compositions listed in Table 1 show that every sample has a good metal composition.

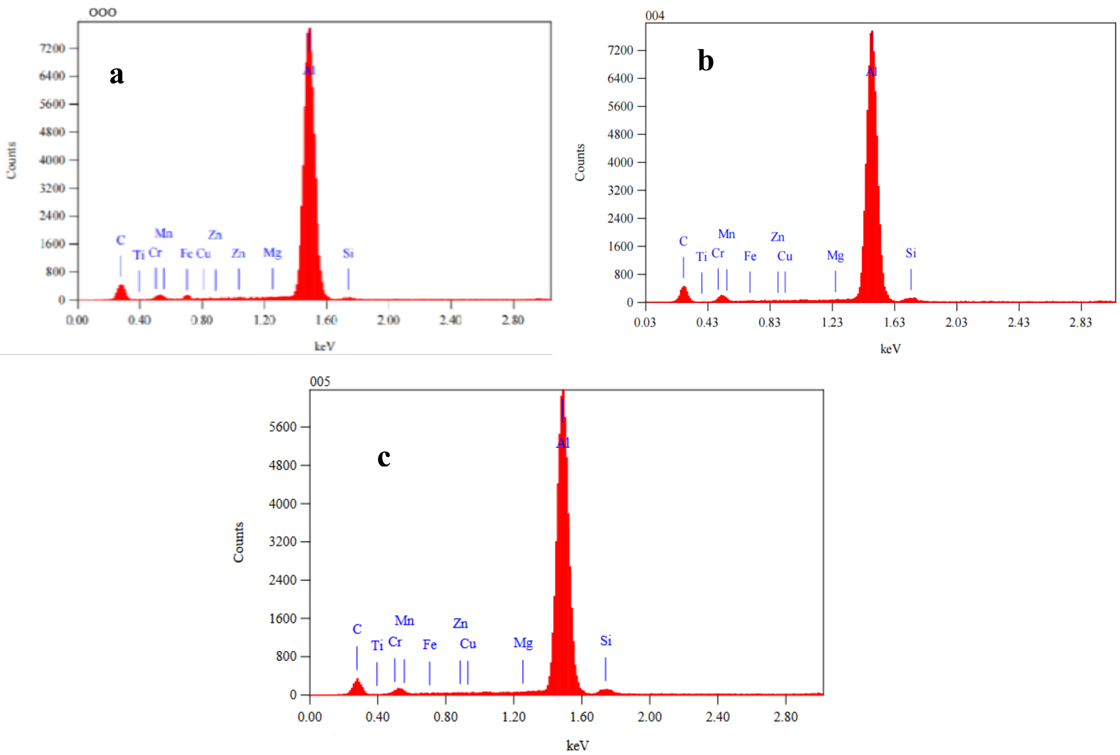

Fig 1. EDS spectra pure AA 6061 aluminum and SiC/graphene-based AA 6061 aluminum samples.

Table 1.Metal compossitions of pure AA 6061aluminum and SiC/graphene-based AA 6061 aluminum samples.

Samples	Cu	Cr	Fe	Mg	Mn	Si	Ti	Zn	C	Al
Sample1	0.15	0.1	0.5	0.9	0.3	0.1	0.6	0.5	ND	Remains
Sample2	0.03	0.07	0.43	ND	0.21	1.01	ND	ND	12.48	Remains
Sample3	ND	0.12	0.10	ND	ND	1.37	0.07	ND	10.95	Remains

Investigations into the microstructure of the composites were conducted at different magnifications using an electron gun scanning electron microscope (SEM).The AA6061 alloy images show that the Al has an irregular shape with an average particle size of 1–5 µm, while the SiC/graphene added the shape of microstructure enhance shown sample 2 in Fig 2(b). Further increased SiC/graphene the shape increased in sample 3 shown in Fig 2(c).The structure growth increased by adding composites and synthesis parameters.

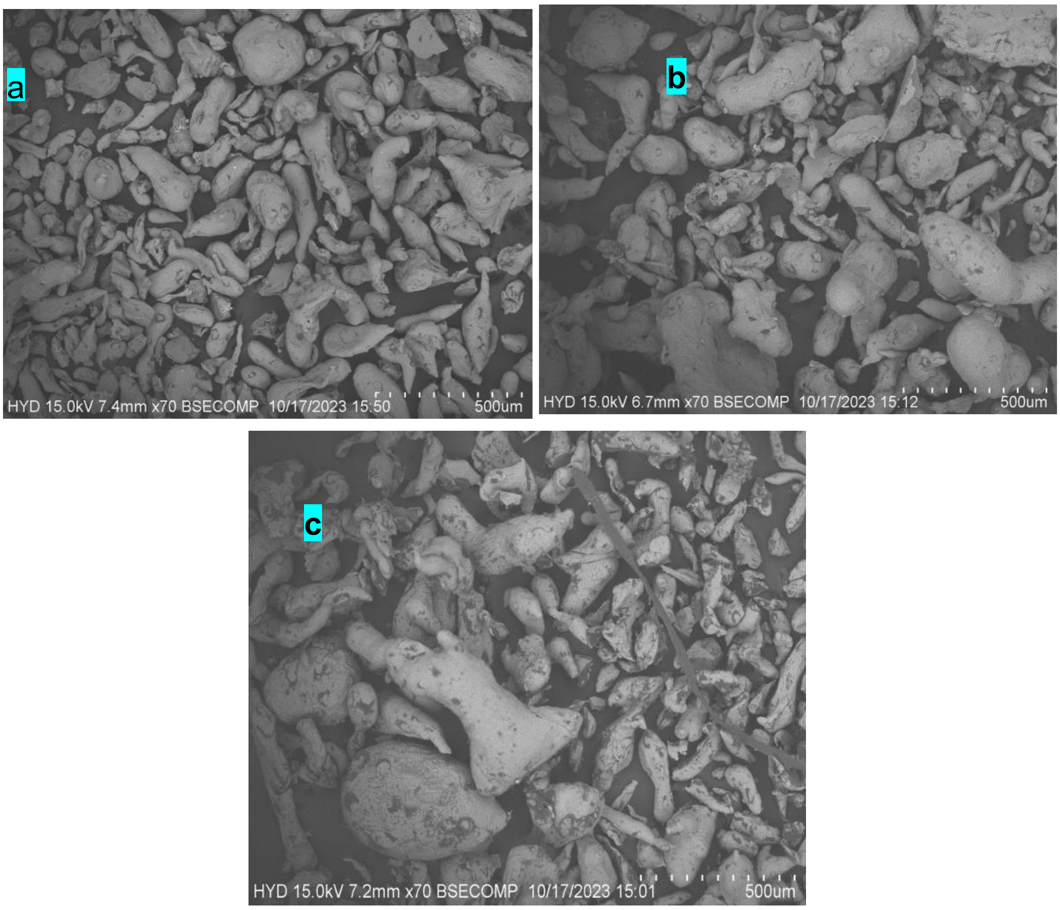

Fig 2. Morphology of pure AA 6061 aluminum and SiC/graphene-based AA 6061 aluminum samples.

Table 2 shows the pure AA 6061aluminum and SiC/graphene-based AA 6061aluminum samples. It has been discovered that dopant addition increases the hardness of the matrix. The impact of SiC and graphene weight percentage on hardness variation in the AA6061 alloy is demonstrated in Fig 3. It has been noted that the hardness of the matrix increased with the weight % of SiC and graphene in the matrix. There is a hardness of 93 for sample 3. Previous research also observed that reinforcements increased the hardness of the base materials [20-21].This observation demonstrated that grain refinement; most likely as a result of dynamic recrystallization [22]. Higher hardness properties were ultimately the consequence of this greater grain improvement. Additionally, every reinforcement particle's intrinsic characteristic was important.

The varying percentages of SiC/graphene have extremely high hardness values. As a result, the AA 6061 matrix's inclusion and dispersion of these particles have made up for the unreinforced material's hardness loss. Sample 3 had the greatest increase in hardness out of the three samples. This was explained by the reinforcement particle's exceptional hardness and uniform particle distribution, which improved the aluminum matrix's grain refinement.

Table 2.Mechanical properties of pure AA 6061aluminum and Sic/graphene-based AA 6061aluminum samples.

Sample	Compression Strength (MPa)	Hardness (Shore A)	Coefficient of Friction	Salt Spray Corrosion
Sample1	4.90	55	0.58	The given samples are subjected to salt spray corrosion test for 24 hours, found free from red rust formation
Sample2	4.10	90	0.45	The given samples are subjected to salt spray corrosion test for 24 hours, found free from red rust formation.
Sample3	4.34	93	0.43	The given samples are subjected to salt spray corrosion test for 24 hours, found free from red rust formation.

Have a significant impact on how the wear mechanism of a material is determined by its wear response [23]. Figure 4 shows how the Al6061 alloy and composite Al6061/SiC/graphene react over time to specific wear loss at a constant temperature. Additionally, the results demonstrate that composites made from hybrid materials have a lower particular wear rate as basic alloys, which may be explained by the higher hardness of the hard ceramic particles. Particle hardening and hardening provide higher resistance to material release [23-25].Furthermore, it is discovered that for all hybrid composite compositions based on hardness value, the wear rate is reduced as the true area of contact—which is defined as the ratio of applied load to pin material hardness—decreases with increasing hardness. When taking into account the influence of load, specific wear rate falls as with time. One crucial metric that is also taken into consideration for this inquiry is the coefficient of friction (COF). The change of COF for samples in Table 2. The results show that, for practically all operating situations and compositions, the coefficient of friction increases decreases with the adding of particle

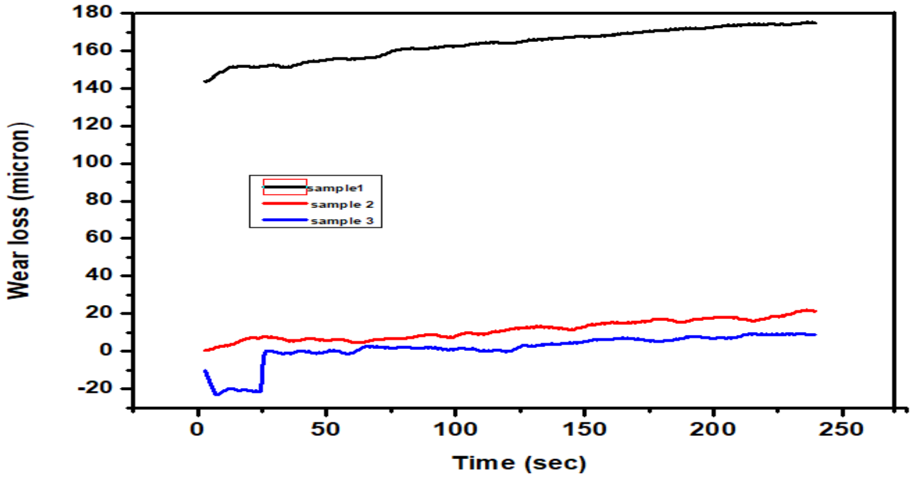

Fig 4. Wear loss of pure AA 6061 aluminum and SiC/graphene-based AA 6061 aluminum samples.

How does the frictional force variation change for pure AA 6061 aluminum and SiC/graphene-based AA 6061 aluminum samples at varying time. Frictional force varies in magnitude from 3.0 to 6.5 N. For the composites observed 5 hours, the frictional force fluctuation reaches its maximum. Frictional force values for the composites at 5 to 6.5 N. The fact that the frictional force was smaller suggests that the composites had less wear. The abrasion of particles with low values may be the cause of this. Delamination causes a greater amount of material wear when there is a strong force of friction among the disc area and the pin [26]. This conclusion is consistent with the findings of Sahin and Acilar [27], They noted that a rise in composite wear loss was correlated with a rise in the amount of friction that exists between the surfaces in contact.

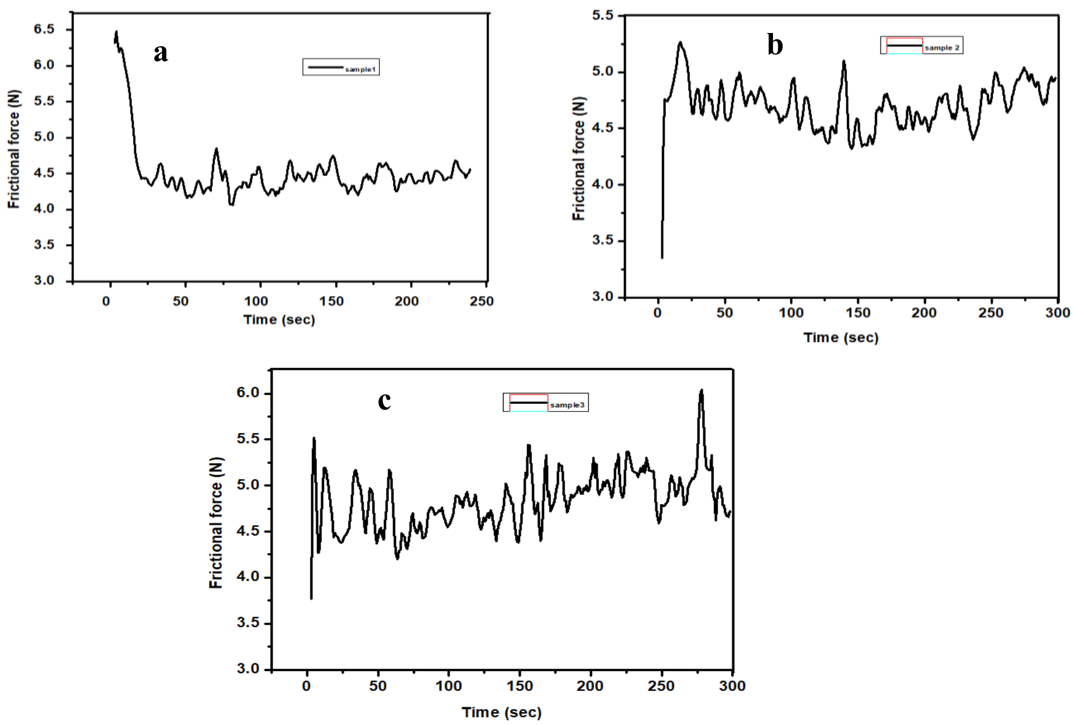

Fig 5. Frictional force of pure AA 6061 aluminum and SiC/graphene-based AA 6061 aluminum samples.

4.Conclusions

This investigation evaluated the impacts of composite weight percentage on wear behavior and friction using powder metallurgy techniques to create Al 6061 hybrid metal matrix composites. A higher concentration of SiC/graphene particles in the composites boosts their wear resistance and, over time, their hardness. Increasing reinforcement has the dual effects of lowering the coefficient of friction and increasing wear resistance in metal matrix composites. A longer endurance time decreases the wear of composites and un reinforced alloys.

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