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Study of Wear Properties on Aluminium alloy Composite Reinforced with Graphene

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Abstract:** Rapid innovation in nanotechnology in recent years enabled development of advanced metal matrix nano composites for structural engineering and functional devices. As one of the most important engineering material, Aluminium alloy having low weight and high strength results in good structural rigidity. Carbonous material like graphene and it possess unique electrical, mechanical, and thermal properties. Owe to their lubricious nature, the graphene material have attracted researchers to synthesize lightweight self-lubricating metal matrix nano composites with superior mechanical and tribological properties for several applications in automotive and aerospace industries. In this study, matrix material AA6061 reinforced with different filling content of graphene was fabricated by powder metallurgy technique. The specimens were conducted through wear test. The wear loss and wear rate is evaluated by varying the parameters load, speed, sliding distance and time. It is observed that AA6061 reinforced with Graphene shows better performance than AA6061 without Graphene.
Keywords: Graphene, Wear test, AA6061, PM, etc.

I. INTRODUCTION

In MMCs, different alloys of aluminium, magnesium, copper, or nickel are generally used as matrix materials. Among these materials aluminium alloys are the most widely used because of their outstanding properties such as light weight, high strength, high modulus, low coefficient of thermal expansion and good wear resistance. Depending on final desired properties of composites, different reinforcement is used in aluminium matrix composites. Al_2O_3, SiC are very commonly used reinforcement materials. Superlight materials with high mechanical strengths are always in demand in many industrial fields, especially those that produce transportation machines, such as automobiles, trains, ships, and aviation technologies. Among various reinforcements, recent emerging material Carbonous materials such as graphite, carbon nanotubes, and diamond etc. Graphene can be synthesized from graphite using different technique which is found to have many favourable properties such as electrical, mechanical, thermal and tribological properties for several applications. Over the past decade, carbon nanotubes (CNTs) have been extensively used as reinforcement of aluminium, to meet high and ever increasing demand of structural strength. Graphene is a two dimensional structures can be dispersed in all kinds of solvents and matrices easily as compared to CNTs. Therefore we are confident to replace the CNT/Al composite by Graphene/Al composite in future using different techniques. Powder metallurgy techniques (PM) which consist of basic three steps (mixing, compacting, and sintering) offers homogeneous and uniform distribution of reinforcement particles in the matrix. As ball milling is considered a big problem because it produces heat which can burn graphene powder easily. Therefore this method can be an alternative of ball milling and it has a great potential for synthesis of Al based matrix nano-composite which is considered good for engineering applications. In this case study, have fabricated graphene reinforced aluminium alloy (6061) matrix composite material through powder metallurgy technique to study wear properties by conducting pin on disc tests and to attain improved properties by varying the graphene content in composite material. Aluminium based metal matrix composites (MMCs) can be obtained by diffusing reinforcement particles in metal Al using liquid phase methods.

II. FABRICATION AND TESTING

A. Matrix and Reinforcement selection

Aluminium 6061 alloy with 99% purity have been selected as matrix material for composite preparation.

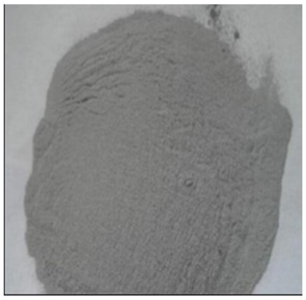

Fig.2.1 (a) Aluminium alloy powder

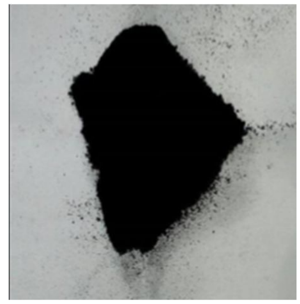

Fig.2.1 (b) Graphene powder

Graphene used as reinforcement materials due to its self-lubricating property during tribological condition. Also which increase the strength, corrosion and wear resistance and to provide a glossy texture to the alloy. Aluminium, 6061alloys and graphene powder shown in fig: 2.1(a), fig: 2.1(b) and fig: 2.2.

Fig.2.26061 Alloy materials

TABLE: 2.1 Chemical Composition of Al 6061

Material Composition	Wt. %
Chromium	0.25
Copper	0.35
Magnesium	1
Zinc	0.2
Iron	0.5
Manganese	0.1
Silicon	0.5
Titanium	0.1
Aluminium	Balance

B. Blending

Blending of powders is defined as the thorough intermingling of powders of the same nominal composition. The implication with blending is that constituents in the vessel are virtually identical except for some minor physical characteristics. At first Aluminium and alloy powders were blended in acetone for an hour. After blending, Graphene with particle contents was slowly added to the aluminium alloy powder slurry in acetone. Mixing process was continued for one hour using mechanical agitator to obtain the homogeneity in mixture. The mechanically agitated mixture was filtered and dried in oven for 2 hours to obtain the composite powder.

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C. Compacting

Powder compaction is the process of compacting metal powder in a die through the application of high pressures. The prepared Al-Graphene mixture was pressed with hydraulic load is gradually applied about 100KN by UTM machine in a compacting die with the cavity dimensions of diameter 8 x 19 mm. For easy taking out the samples, the grease was applied outer surface of punch and inner hollow surface of die.

Fig.2.3 Die mounted on UTM machine

D. Sintering

Sintering is the process of compacting and forming a solid mass of material by heat or pressure without melting it to the point of liquefaction. The atoms in the materials diffuse across the boundaries of the particles, fusing the particles together and creating one solid piece. After compacting, the specimen is ready of required dimension of 8 x 19 mm, sintering must be done to have an internal strength and to have a better properties, the green billets were sintered in vacuum muffle furnace at 450^0c for 3hours with the increment rate of 10^0c and cooling rate of 20^0c gradually cooled to room temperature to obtain enhanced strength in the rods of 8mm diameter.

Fig.2.4 (a) Before sintering

Fig.2.4 (b) After sintering

E. Wear test

The wear specimen was of a pin type which were slide against a hardened steel at various loads, such as 1kg, 2kg, 3kg and speed of 400rpm at a track diameter of 105mm. The slider disc is made up of EN31 hardened steel disc with hardness of 60 HRC. The pin test sample dimensions were of 8mm diameter and 19mm height, which are made according to ASTM G99 standards and are cylindrical in shape. Care should be taken to note that the test sample's end surfaces were flat and polished metallographically prior to testing. The wear machine which is used in conducting the test as shown in fig: 2.5. The weight of the pin is measured by an electric weighing balance, which has an accuracy of 0.001gm, before and after the test to calculate the weight loss.

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Fig: 2.5 Pin on Disc testing machine

III. RESULTS AND DISCUSSION

The most common tests performed on metal include wear properties i.e. wear loss and wear rate. Uniform distribution of the particles is a pre-requisite to enhance the tribological properties of the matrix. This test provide a reasonably good baseline for a metal sample assuming that it is large enough to do tests, is uniform in composition, and is uniform in wear resistances. To see the difference in graph of Graphene-AA6061 nano composite when varying load, speed and distance. The test was carried out by keeping constant distance 2000 m and speed in 400rpm and changing the load range of 1, 2 and 3kg.

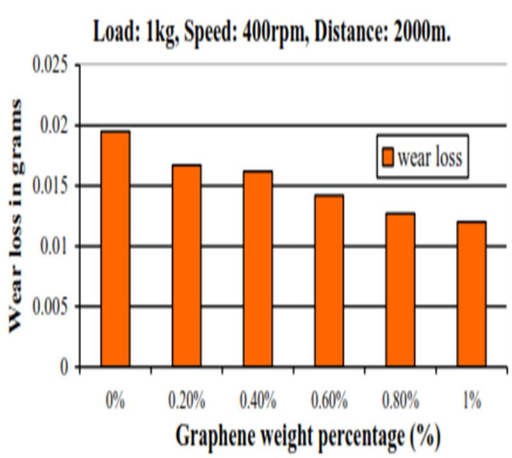

Fig: 3.1 (a) Wear loss v/s Graphene

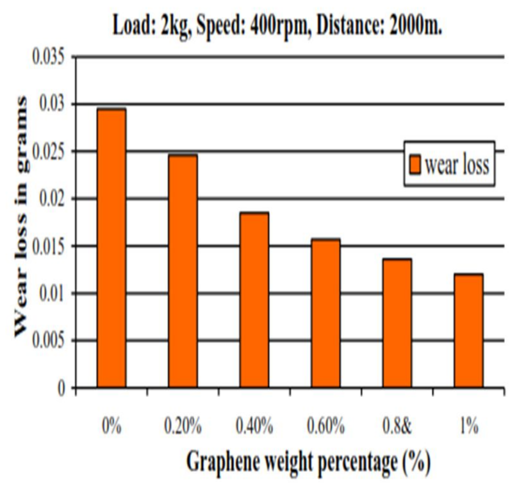

Fig: 3.1(b) Wear loss v/s Graphene

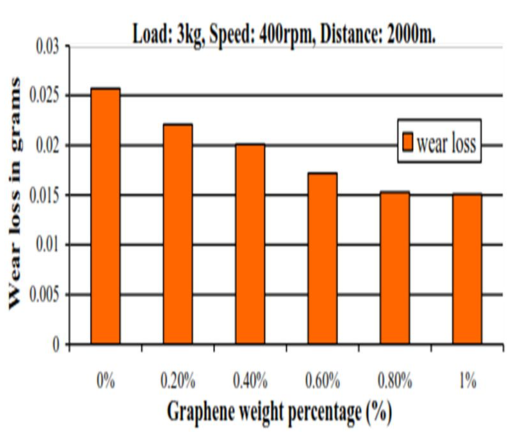

Fig: 3.1 (c) Wear loss v/s Graphene

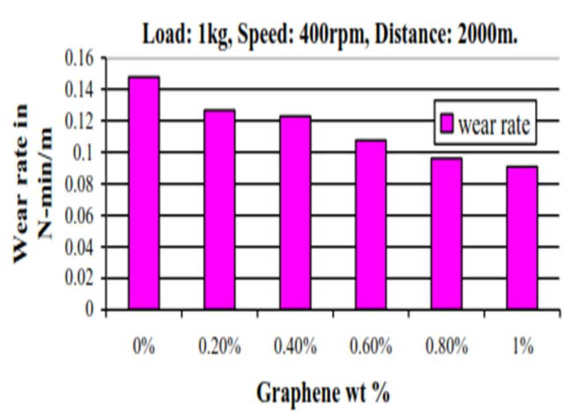

Fig: 3.2 (a) Wear rate v/s Graphene

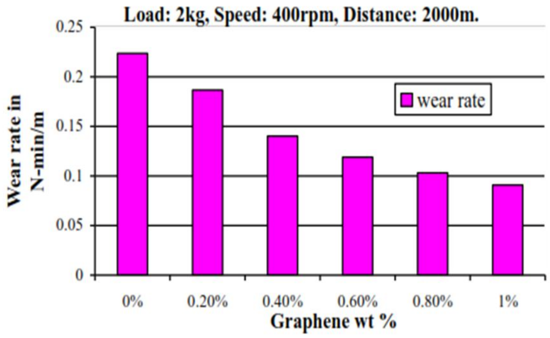

Fig: 3.2 (b) Wear rate v/s Graphene

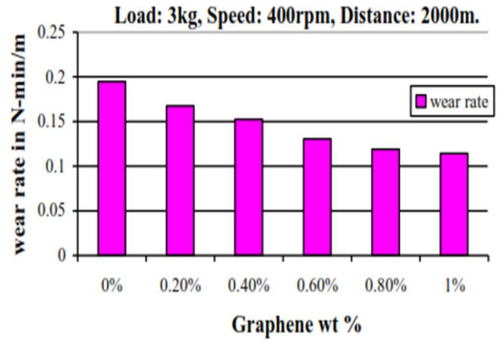

Fig: 3.2 (c) Wear rate v/s Graphene

In Above Figures from 3.1 & 3.2 found that, under mild wear conditions, the composite displayed lower wear loss, wear rate and friction coefficient compared to aluminium. It was clear that friction and wear behaviour of Al-Graphene composite is largely influenced by applied load and there exists a critical load beyond which graphene nano particles could have negative impact on wear resistance of aluminium alloy. The wear loss and wear rate is inversely proportional to the Graphene weight percentage, as the Graphene wt% increases the wear rate and wear loss decreases for various load 1kg, 2kg and 3kg, Speed 400rpm and Distance 2000m. This reveals that the addition of reinforcement in the composites will decreases wear loss and wear rate.

IV. CONCLUSIONS

The Aluminium Graphene nano-composite has been successfully synthesized through powder metallurgy process. The Graphene with Aluminium matrix composites, comparing with conventional Aluminium matrix composites, and has an immense potential to fabricate the composite reinforced with Graphene having important properties. This means that outcome of composite will possess outstanding tribological properties. Although some positive results have been achieved by dispersion of Graphene in aluminium metal matrix are as follows:

A. The result graph i.e. wear loss v/s Graphene wt % is clear that the wear loss decreases with increase in reinforcement weight of (0.8% and 1%) graphene particles.
B. The result graph i.e. wear rate v/s Graphene wt % is clear that wear rate decreases with increase in reinforcement weight of (0.8% and 1%) Graphene particles.

Ultimately by this work is concluded that the wear loss, wear rate properties are decreased by adding reinforcement (Graphene) to the AA6061 matrix composite and the above properties are not decreased without adding graphene to the same.

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