Study on Two Body Wear and Three Body Wear of Carbon Reinforced Epoxy Composites: A Review

Nithin. G [1], Haseebuddin M. R [2], Bhaskar Pal [3], Md Ayaz Masih [1],
Md Faizal Akhter. [1]
[1] PG Scholar, Dept. of Mechanical Engg, Dayananda Sagar College of Engineering, Bangalore.
[2] Research Scholar, Dept. of Mechanical Engg, Dayananda Sagar College of Engineering, Bangalore.
[3] Professor & Head, Dept. of Mechanical Engg., Alliance College of Engineering & Design,
Alliance University, Bangalore.

***Abstract:-* The influence of various fillers on the tribological properties of the carbon reinforced epoxy composite is analyzed in this paper. Carbon fiber has high initial strength to weight ratio and hence, it finds application in aviations, automotives and in many other areas. The fatigue endurance limit of the carbon fiber reinforced epoxy composites is one of its primary characteristic drawbacks. Hence, it is important to know the mechanical and wear behavior of carbon reinforced epoxy composites. As it is intended to study the wear behavior of carbon-epoxy composites with varying percentages of nano fillers, a effort has been done to compare the effect of various fillers on two body wear and three body abrasive wear of polymer composites**.

1. INTRODUCTION

Composite materials [1] are new generation materials which are developed to meet the growing demands of new technology. The main advantage of composite materials is its strength and stiffness along with the low weight.

Composite materials are made up of two or more constituents which are distinct and separate at macroscopic level which combines together to form a composite. Basically, it consists of two main components called matrix and reinforcement. Matrix holds the reinforcement and supports it by maintaining the relative positions. Reinforcements are the materials introduced into the matrix to give the greater strength.

Polymer matrix Composites (PMC’s) consists of a polymer resin as matrix and fibers as the reinforcement. In PMC, polymerization reaction occurs due to which linked are formed between the matrix materials increasing its strength. PMC has great diversity of applications due to its large strength to weight ratio. Based on reinforcement types, polymer composites are classified as glass, carbons, aramid etc.

Carbon fibre reinforced polymer (CFRP) composites uses carbon fibre as reinforcement. Carbon is a high performance fibre materials and is very strong and light fibres of about 5-10 micrometer in diameter and are composed of carbon atoms . Carbon fibres are produced through carbonization of polyacrylonitrile fibers and Pitch resins at high temperature. Carbon fibres contains 90% carbon which is obtained by pyrolysis of required fibres . Carbon fibres are expensive in production but has high strength to weight ratio . Due to its desirable properties it is used in aviation , automotive and in many other areas.

The interfacial adhesion between fibers and matrix improves the mechanical behavior of CFRP. Carbon fibers came into existence in 1879 by Edison [2]. However, its successful commercial production was started in early 1960s.

Polymer based composites play a vital role in design . polymers and its composites sometimes encounter hard abrasive surfaces . some instances like pipe and chute liners , earth movers, impellers in pump , rotors of powder mixers , sleeves and bearings assembled in machineries subjected abrasive forces , chain wear strips and etc. Different combinations of fiber, fillers and reinforcements have been used to bring out viable hybrid composites with enhanced tribological and mechanical properties .

This paper quotes such hybrid composites which has shown enhanced properties and has helped in our literature review .

Hybrid polyaryletherketone has shown enhanced mechanical properties such as high strength, modulus of elasticity, better toughness, higher wear resistance and better thermal stability [3] .

Hybrid Carbon Fiber Reinforced Polymer (CFRP) with Alumina as a filler material - Initially Carbon Fiber Reinforced Polymer composites showed a steady decline in its surface hardness and its impact properties. Due to inclusion of Alumina into the composites , improved hardness and its impact strength was noticed. The results is seen in the graph plotted 1.1 and 1.2 [4].

Hybrid Glass Epoxy composites using Alumina as a filler material – With the inclusion of Alumina as a filler material , the composite’s micro hardness , density and flexural properties were greatly influenced. The abrasive wear rate decreased with increase in sliding distance [5].

2 EXPERIMENTAL PROCEDURE

Two Body Adhesive Wear Test: The two body adhesive wear behavior is studied out using a pin-on-disc machine on the hybrid carbon reinforced polymer , as per ASTM G99. The schematic diagram of the two body wear setup is shown in Fig. 2.1.

The tests are carried out on samples glued to a shaft of diameter 8mm and length 25mm. This specimen sample resembles the pin. The shaft is then fixed on the specimen holder by applying dead weights. The duration for conducting the test for each specimen is calculated with respect to the sliding distance for that specimen using the formula:

$d=2\pi RNt$

where,

d = sliding distance (m)

R = track radius (25×10^{-3} m)

N = rpm of steel wheel

t = time of wear (min)

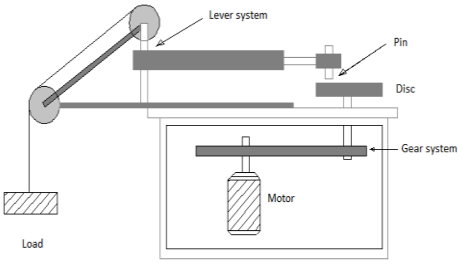

Fig. 2.1: Schematic representation of pin-on-disc set- up.

The flat surface of the specimen pressed against the face of sand grit wheel using the lever mechanism and the specimen is subjected to wear by the rotation of the wheel .The rotational speed of the wheel is fixed at 200rpm throughout the tests. The tests are conducted at different sliding distances up to 1000m in steps of 250m and applied loads (24N and 48N). The wear loss is calculated by calculating the difference in weight of the specimens before and after wear tests.

Table 2.1 : Test parameters

Sliding Distance(m)	250, 500, 750, 1000
Load(N)	23, 32
Track radius(mm)	25
Speed Of Wheel(rpm)	200

Three- Body abrasive wear behavior : Three- body abrasive wear behavior of the carbon fiber reinforced is studied using dry sand/ rubber wheel abrasive wear test rig. The schematic diagram is shown in figure 2.2. The specimen is fixed with the help of the specimen holder and the abrasive particles are introduced between the test specimen and the rotating wheel. The test specimen is pressed against the rotating wheel by applying suitable loads which rotates the levers about it's pivot axis which is tangential to the surface of the wheel .

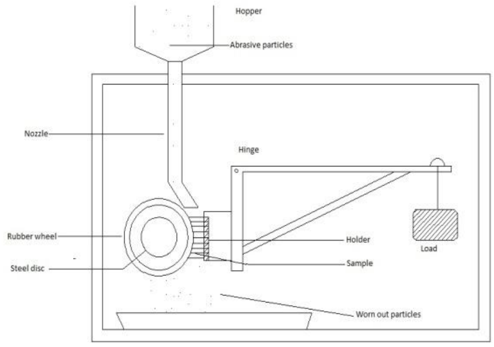

Fig. 1.2: Schematic representation of three body abrasive test wear rig .

TESTING PARAMETERS

Rotating speed(m/s)	2.4
Abrasive Particles	Silica Sand
Sand Flow Rate(g/min)	250 +/- 5

3. RESULTS :

1) The graph shown in figure 3.1 , discusses the result of the two body wear test conducted on polyetheretherketone with 30% glass fiber, polyetheretherketone with 30% carbon fiber, polyetherketone with 30% glass fiber, polyetherketoneketone with 30% carbon fiber, polyetheretherketone with 10% carbon fiber, polyetherketoneketone with 10% carbon fiber, carbon fiber reinforced epoxy resin composites with 7% Al filler. The graph discusses the wear volume for the specimens (A, B, C, D, E, F, G) with respect to the sliding distance. From the graph, it is evident that carbon fiber reinforced epoxy resin composite with 7% Al filler has the least wear volume .

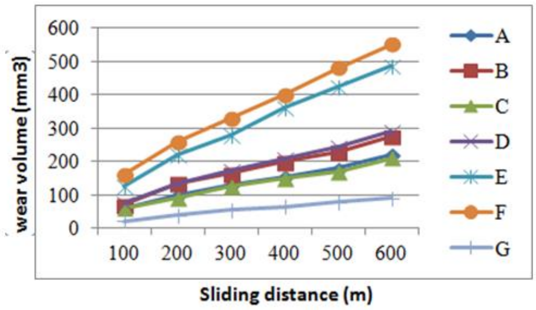

Fig 3.1 : Two Body Adhesive wear Graph

A – polyetheretherketone with 30% glass fiber

B- polyetheretherketone with 30% carbon fiber

C- polyetherketone with 30% glass fiber

D- polyetherketoneketone with 30% carbon fiber

E- polyetheretherketone with 10% carbon fiber
F- polyetherketoneketone with 10% carbon fiber
G- carbon fiber reinforced epoxy resin composites with Alumina filler

2) The graph shown in figure 3.2 , discusses the result of the three body wear test conducted polyetheretherketone with 30% glass fiber, polyetheretherketone with 30% carbon fiber, polyetherketone with 30% glass fiber, polyetherketoneketone with 30% carbon filler, glass fiber reinforced + epoxy + Al2O3, glass fiber reinforced + epoxy + pine bark dust, reinforced glass fiber + epoxy + SiC, polyetheretherketone with 10% carbon fiber+ PTFE+ graphite filler , polyetherketoneketone with 10 % carbon fiber+PTFE+ graphite filler,carbon fiber reinforced epoxy resin composites with Al fiber. The graph discusses the wear volume for the specimens (A, B, C, D, E, F, G, H, I, J) with respect to the sliding distance. From the graph, it is evident that carbon fiber reinforced epoxy resin composite with 7% Al filler has the least wear volume.

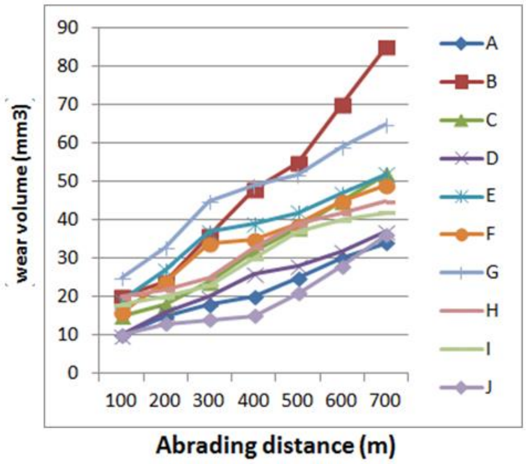

Fig 3.2: Three Body Abrasive Wear Graph

**The correlate the various research, the data used in the graph has been interpolated.

A – polyetheretherketone with 30% glass fiber
B – polyetheretherketone with 30% carbon fiber
C – polyetherketone with 30% glass fiber
D – polyetherketoneketone with 30% carbon filler
E - glass fiber reinforced + epoxy + Al2O3
F – glass fiber reinforced + epoxy + pine bark dust
G - reinforced glass fiber + epoxy + SiC
H – polyetheretherketone with 10% carbon fiber ,PTFE, graphite filler.
I – polyetherketoneketone with 10 % carbon fiber, PTFE, graphite filler
J – Carbon fiber reinforced epoxy resin composites with Alumina filler.

CONCLUSION:

It is clear from these graphs that wear rate increases as the abrading distance increases and wear rate strongly depends upon the applied load for all the specimen and increases with increase in load.

It is observed from graphs that Carbon fiber reinforced epoxy resin composites with Alumina filler have better two body wear resistance compared to other composites.

In Three body wear test also it is seen that Carbon fiber reinforced epoxy resin composites with Alumina filler shows better performance compared to other composites.

REFERENCES:

1. Dr. H.K. Shivanand, B.V Babu Kiran , 2010, Composite Materials , First Edition, Asian books Pvt ltd.
2. Raghavendra R Hegde , Atul Dahiya, M.G Kamath, Monika kannadaguli , Haoming Rong, April 2004 , Carbon Fibres.
3. A.P.Harha, U.S.Tewari, 2002, Two-body and three-body abrasive wear behavior pf polyaryletherketone composites.
4. Devaraj.E and Haseebuddin M.R. ,2013, IJERT , ISSN:2278-0181, Vol.2 Issue 10 October, Study of mechanical behavior of carbon fiber reinforced epoxy resin composites with alumina filler additions.
5. Amar Patnaik , Alok Satapathy,Sandhyarani Biswas, 2010, Malayasian Polymer Journal, Vol. 5,No. 2,p 37-48,Investigations on Three-body abrasive wear and mechanical properties of particulate filled glass epoxy composites.