International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 8, August - 2014

Synthesis and Characterization of Carbon Epoxy Composite With and Without Filler Material

Kumar R[1]
[1] Research Scholar, R & D, M S Ramaiah Institute of Technology,
Bangalore, Karnataka, India.

Dr. C. N. Chandrappa[2]
[2] Professor, Acharya College of Engineering and Technology,
Bangalore, Karnataka, India.

Vishwanath Koti [3]
[3]Research Scholar, R & D, M S Ramaiah Institute of Technology,
Bangalore, Karnataka, India.

***Abstract*: - A typical composite material is a system of materials composing of two or more materials (mixed and bonded) on a macroscopic scale. Generally, a composite material is composed of reinforcement (fibers, particles, flakes, and/or fillers) embedded in a matrix (polymers, metals, or ceramics). The matrix holds the reinforcement to form the desired shape while the reinforcement improves the overall mechanical properties of the matrix.**

Addition of Al2O3 into carbon strands reinforced epoxy matrix improves the tribological properties of the matrix material. The basic aim of the work is to develop and characterize a new class of composites by using Al_2O_3 filler with an epoxy matrix and carbon fiber as a reinforcing material. Attempt is made to use Al_2O_3 filler in this Carbon fiber reinforced epoxy matrix composites and experiments are conducted in laboratory conditions. Three body wear test has been conducted using dry sand abrasion tester in accordance with ASTM G65 and erosive test had been conducted using air jet erosion tester in accordance with ASTM G 76.

***Keywords*— ASTM, Tribological. Reinforcing material; matrix**

I. INTRODUCTION

Composite materials are engineered materials made from two or more constituent materials with significantly different physical or chemical properties and which remain separate and distinct on a macroscopic level [1] within the finished structure. Composite Materials have come to existence as long as the history of human being is known. The demand for high performance composites was further aggrandized by the high cost of fuel which resulted from the energy crisis during the 1970s. Glass-Fiber-Reinforced Polymer Composites (GFRPs) have found extensive applications including fiber-glass boats, pressure vessels, and airplane panels. Glass fibers are the earliest known fibers in advanced composites compatible with Polyester and Epoxy matrices. Carbon-Fiber-Reinforced Polymer Composites (CFRPs) are known for their strength, durability and light-weight. Application of CFRP includes [2] sport goods and components in aerospace industry.

Current active research areas in composite materials provide some insight into technologies that will mature to practical application in both the short and long terms. While modern composites are in their early stage of progress,[3] there is several worldwide ongoing research themes which are developed based on today's emerging technological challenges in characterization, fabrication and application plotting the future directions for research activities in composite materials.

Manufacturing of composite parts involve distinct operations that may vary depending upon available technology, existing facilities and personnel skill.[4] The manufacturing process also varies due to wide varieties of composite materials and their applications. The mixture of reinforcement and resin does not really become a composite material until the last phase of the fabrication. Manufacturing composite parts for the mass market (automobiles, electricity, and buildings) requires highly automated processing procedures with high productivity.

Curing is one of the important steps which require a lot of attention of researchers, as it plays an important role in achieving the required mechanical properties. 80% of the process time is consumed in the curing of the FRP [5] composite laminates. Lengthy cure cycle time is the major bottleneck which requires extensive research. There are many curing methods such as, Thermal curing, and infrared curing.

II. MATERIALS AND METHODS

First, the polymer composite laminates are fabricated by wet layup technique/hand layup technique and are then cured composites specimen are found using the 3-body abrasive wear tester Erosion characteristics of polymer composites specimen are found using air jet erosion tester.

A.Objectives:

1. Composite Processing – The fabrication of carbon fiber reinforced epoxy composites with and without Al_2O_3 as filler
2. To analyze how the material behaves, when the different proportions of Al2O3 to carbon epoxy composites

3. To investigate the wear properties of particulate filled carbon composites
4. To investigate the erosion properties of particulate filled carbon composite at different impinging angles.
5. Preparation and testing [7] of Laminates with higher percentage of Al2O3 can be done and its effect on Mechanical and tribological properties can be studied.
6. Composites with varied content of carbon fibers can also be fabricated and tested for studying the mechanical and tribological properties.
7. Mechanical and Tribological properties can be studied by preparing laminates with different filler materials in varying proportions[8]
8. Wear test can be carried out for higher loading and sliding distances

III. EXPERIMENTS

1) Three body abrasion test:

Three-body abrasion test was conducted as per the ASTM G-65 [6] standards Specimens were cut according to ASTM G-65 standards and cleaned with acetone.
The specimens were weighed and the values noted and clamped in the specimen jaw. Specimens were Selected load was placed on the dead load arm. The sand was filled in the Hooper. The abrading distances were selected and the time corresponding to these values are set. The machine was switched on and the dead load arm was released bringing the specimen in contact with the rotating rubber wheel.
Sand was made to pass between the wheel and the specimen. Upon the wheel coming to rest, the load arm knob is turned removing the contact between the rubber wheel and the specimen. The worn specimen is weighed.
The difference in weigh of the specimen before and after the weight is noted. The test is repeated for different time periods. The entire procedure above was repeated by taking quartz as abrasive. The volume loss and specific wear rate was calculated and results are plotted.

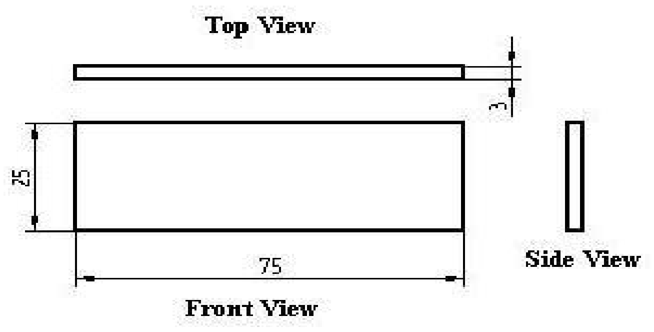

Fig.1:- Three body Abrasive wear test specimen

Test specimens
The wear and friction tests have been conducted on following materials:
a. carbon-epoxy
b. carbon-epoxy+3% Al2O3
c. carbon-epoxy+6% Al2O3
d. carbon-epoxy+9% Al2O3

2) Three body abrasive wear test set up:

- Loads applied (N)=23, 35
- Abrading distance (m) =270, 540, 810, 1040
- Time period (min‟, sec”) =1‟51”, 3‟12”, 4‟33”, 5‟54”
- Rubber wheel diameter (mm) =226
- Material of the rubber wheel = chlorobutyl rubber
- Abrasive = silica
- Abrasive size = 200µ

Load = 23 N
Speed = 200rpm
Abrasive = Sand

Table 1:- Carbon epoxy + 9% Al2O3 results for the three body abrasion test

Sl.No	Abrasive Distance (m)	Time (min’, Sec”)	Weight Loss (g)	Volume Loss (mm^3)	Specific Wear Rate (m^3/Nm) $\times 10^{-11}$
1	270	1’ 51”	0.2108	0.1561	2.514
2	540	3’ 12”	0.2582	0.1912	1.539
3	810	4’ 33”	0.1420	0.1051	0.564
4	1080	5’ 54”	0.5929	0.4391	0.176

Table 2:- Carbon epoxy + 6% Al2O3 results for the three body abrasion test

Sl.No	Abrasive Distance (m)	Time (min’, Sec”)	Weight Loss (g)	Volume Loss (mm^3)	Specific Wear Rate (m^3/Nm) $\times 10^{-11}$
1	270	1’ 51”	0.2108	0.1561	2.514
2	540	3’ 12”	0.2582	0.1912	1.539
3	810	4’ 33”	0.1420	0.1051	0.564
4	1080	5’ 54”	0.5929	0.4391	0.176

Table 3:- Carbon epoxy + 3% Al2O3 results for the three body abrasion test

Sl.No	Abrasive Distance (m)	Time (min', Sec")	Weight Loss (g)	Volume Loss (mm^3)	Specific Wear Rate (m^3/Nm) $\times 10^{-11}$
1	270	1' 51"	0.2108	0.1561	2.514
2	540	3' 12"	0.2582	0.1912	1.539
3	810	4' 33"	0.1420	0.1051	0.564
4	1080	5' 54"	0.5929	0.4391	0.176

Table 4:-Carbon epoxy composite without fillers results for the three body abrasion test

Sl.No	Abrasive Distance (m)	Time (min', Sec")	Weight Loss (g)	Volume Loss (mm^3)	Specific Wear Rate (m^3/Nm) $\times 10^{-11}$
1	270	2'14''	0.1270	0.0940	1.5136
2	540	4'29''	0.1160	0.0859	0.6916
3	810	6'44''	0.1186	0.0878	0.4715
4	1080	8'59'	0.1614	0.1195	0.481

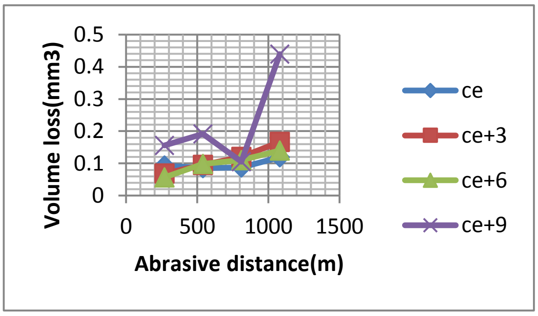

Fig 2:-Abrading distance v/s specific wear rate using sand as abrasive (23N)

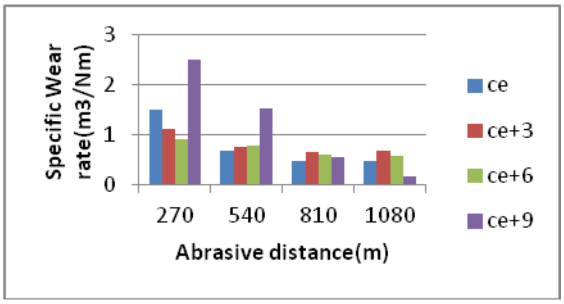

Fig 3:-Abrading distance (m) v/s specific wear rate (m^3/Nm)

3) Trial 2

Load =35 N
Speed = 200rpm
Abrasive = Sand

Table 5:- Carbon epoxy results for the three body abrasion test

Sl.No	Abrasive Distance (m)	Time (min', Sec")	Weight Loss (g)	Volume Loss (mm^3)	Specific Wear Rate (m^3/Nm) $\times 10^{-11}$
1	270	2'14''	0.1616	0.1197	1.266
2	540	4'29''	0.2925	0.2166	1.146
3	810	6'44''	0.4858	0.3598	1.269
4	1080	8'59''	0.4348	0.3220	0.852

Table 6:- Carbon epoxy + 3% Al_2O_3 results for the three body abrasion test

Sl.No	Abrasive Distance (m)	Time (min', Sec")	Weight Loss (g)	Volume Loss (mm^3)	Specific Wear Rate (m^3/Nm) $\times 10^{-11}$
1	270	2'14''	0.1975	0.1462	1.548
2	540	4'29''	0.3041	0.2252	1.191
3	810	6'44''	0.4315	0.3196	1.127
4	1080	8'59''	0.5563	0.4120	1.090

Table 7:- Carbon epoxy + 6% Al_2O_3 results for the three body abrasion test

Sl.No	Abrasive Distance (m)	Time (min', Sec")	Weight Loss (g)	Volume Loss (mm^3)	Specific Wear Rate (m^3/Nm) $\times 10^{-11}$
1	270	2'14''	0.2118	0.1568	1.66
2	540	4'29''	0.3494	0.2588	1.369
3	810	6'44''	0.4318	0.3198	1.128
4	1080	8'59''	0.5517	0.4086	1.081

Table 8:- Carbon epoxy + 9% Al_2O_3 results for the three body abrasion test

Sl.No	Abrasive Distance (m)	Time (min', Sec")	Weight Loss (g)	Volume Loss (mm^3)	Specific Wear Rate (m^3/Nm) $\times 10^{-11}$
1	270	2'14''	0.1084	0.0802	0.849
2	540	4'29''	0.3720	0.2755	1.457
3	810	6'44''	0.4730	0.3503	1.235
4	1080	8'59''	0.6530	0.4837	1.279

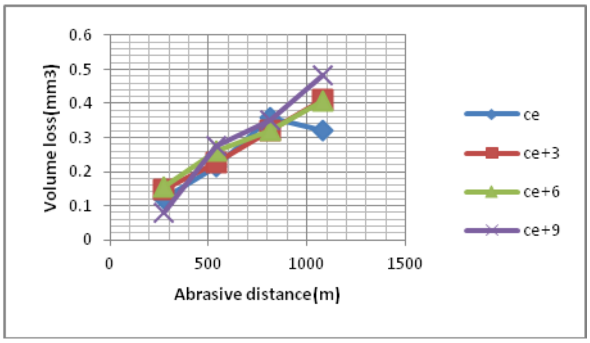

Fig 4 :- Abrading Distance (m) vs Volume loss (mm^3)

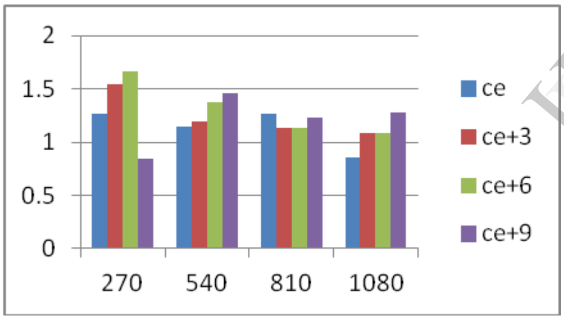

Fig 5:- Abrading distance (m) v/s Specific Wear Rate (m^3/Nm)

IV. RESULTS AND CONCLUSION

Experimental data on the volume loss of Al_2O_3 filled and unfilled composite samples are C-E composites using sand as abrasive. The graph shows the volume loss under different impinging angles. From the graph it can be seen that 9% Al_2O_3 filled specimen as shown the maximum weight loss. It can also be observed that by increasing in the impinging angle there is decrease in weight loss thus very less material gets eroded.

An experimental study of three body wear tests of the carbon fiber reinforced epoxy composite with and without Al_2O_3filler at different loads and sliding distance reveal the following characteristics. Abrasive wear of carbon fiber reinforced epoxy composite strongly depends on the experimental test parameters such as load and sliding distance. Comparative wear performance of all the composites at different loads shows that volume loss has increased and specific wear rate has decreased with increase in load and higher abrading distance. Al_2O_3 filler provides better abrasion resistance as compared to the carbon fiber reinforced Epoxy composites without Al_2O_3 additives. The primary reasons for adding fillers and reinforcing fibers to polymers are to improve their wear property. From the experiment results it was observed that wear rate decreased with increasing filler content.

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