

# Tribological Properties of Vinyl Ester Based Hybrid Composite with $TiO_2$ , $Al_2O_3$ & $MoS_2$ Fillers

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## ABSTRACT

Composite materials play a vital role in many industrial applications. Researchers are working on fabrication of new composite materials worldwide to enhance the applicability of these materials. In view of this the mechanical performance of the composite material is essential. The aim of this project is to assist in the main objective of optimizing the quantity of the filler material  $Al_2O_3$ ,  $TiO_2$  and  $MoS_2$ . Thus the mechanical properties as well as the wear properties of 7.5%, 10% and 12.5% of the filler material as mentioned above has been investigated to obtain an optimum composition for the application in suitable fields.

The purpose of this project is to perform an experimental study of the pin on disc wear of neat Vinyl Ester and  $Al_2O_3$ ,  $TiO_2$  and  $MoS_2$  filler of 7.5%, 10% and 12.5% filled particulate reinforced composites have been investigated along with the subsequent study of the Wear Properties of the material with the intention to contribute to the final aim of optimizing the composition of the composite material.

The investigation is carried out by mixing different weight percentages of the powder with the polyester resin and preparing individual samples. After CSM preparation, the materials were properly mixed using the hand-lay techniques and different specimens were prepared with different compositions of the powder. After all the samples were prepared, Wear Testing is done by pin on disc Wear Testing Machine in ASTM-G99 standard using abrasive paper. The load applied 1KN, 2KN and 3KN in this experiment with sliding distances of 353.25m, 706.5 and 1059.75m respectively.

**Keywords:** Aero space, Auto mobile sector, Composite material, Engineering and Technology

## I. INTRODUCTION

The development of composite materials and related design and manufacturing technologies is one of the most important advances in the history of materials. Composites are multifunctional materials having unprecedented mechanical and physical properties that can be tailored to meet the requirements of a particular application. Many composites also exhibit great resistance to high temperature corrosion and oxidation and wear. These unique characteristics provide the mechanical engineer with design opportunities not possible with conventional monolithic materials. Composites technology also makes possible the use of an entire class of solid materials, ceramics, in application for which monolithic versions are unsuited because of their great strength scatter and poor resistance to mechanical and thermal shock. Further, many manufacturing processes for composites are well adapted to the fabrication of large, complex structures, which allows consolidation of parts, reducing manufacturing costs.

## II. WEAR TESTING

Wear is a process of removal of material from one or both of two solid surfaces in solid state contact. As the wear is a surface removal phenomenon and occurs mostly at outer surfaces, it is more appropriate and economical to make surface modification of existing alloys than using the wear resistant alloys.

## III. MATERIAL AND METHODS

### Materials

Vinyl Ester and  $Al_2O_3$ ,  $TiO_2$  and  $MoS_2$  filler of 7.5%, 10% and 12.5%

### Loads

The load applied 1KN, 2KN and 3KN in this experiment with sliding distances of 353.25m, 706.5 and 1059.75m respectively.

### Fabrication process

Hand lay-up or contact moulding is the oldest and simplest way of making fiber glass resin composites. Fibers can be laid onto a mold by hand and the resin is brushed on. Frequently, resin and fibers are applied on to the mold surface. The deposited layers are densified with rollers. Below showing the schematic of this process, accelerator and catalysts are frequently used. Curing may be done at room temperature or at a moderately high temperature in an oven.

## EXPERIMENTAL PROCEDURE OF WEAR TEST

In this study, Pin-on-Disc testing method was used for tribological characterization. The test procedure is as follows:

Initially, pin surface was made flat such that it will support the load over its entire cross-section called first stage. This was achieved by the surfaces of the pin sample ground using emery paper (80 grit size) prior to testing Run-in-wear was performed in the next stage/ second stage.

This stage avoids initial turbulent period associated with friction and wear curves

Final stage/ third stage is the actual testing called constant/steady state wear. This stage is the dynamic competition between material transfer processes (transfer of material from

pin onto the disc and formation of wear debris and their subsequent removal). Before the test, both the pin and disc were cleaned with ethanol soaked cotton (Surappa et al 2007) Before the start of each experiment, precautionary steps were taken to make sure that the load was applied in normal direction. Figure represents a schematic view of Pin-on-Disc setup. The pin was held against the counter face of a rotating disc (EN31 steel disc) with wear track diameter 45 mm. The pin was loaded against the disc through a dead weight loading system. The wear test for all

specimens was conducted under the normal loads of 1000N, 2000N and 3000N a sliding velocity of 2 m/s. Wear tests were carried out for a total sliding distance of approximately 3000 m under similar conditions as discussed above. The pin samples were 30 mm in length and 12 mm in diameter. The surfaces of the pin samples were slides using emery paper (80 grit size) prior to test in order to ensure effective contact of fresh and flat surface with the steel disc. The samples and wear track were cleaned with acetone and weighed (up to an accuracy of 0.0001 gm using microbalance) prior to and after each test. The wear rate was calculated from the height loss technique and expressed in terms of wear volume loss per unit sliding distance. In this experiment, the test was conducted with the following parameters:

1. Load
2. Speed
3. Distance

In the present experiment the parameters such as speed, time and load are kept constant throughout for all the experiments.

### Wear test calculation

#### Weight Loss

The alloy and composite samples are cleaned thoroughly with acetone. Each sample is then weighed using a digital balance having an accuracy of  $\pm 0.1$  mg. After that, the sample is mounted on the pin holder of the tribometer ready for wear test. For all experiments, the sliding speeds are adjusted to 2 m/s. The specific wear rates of the materials were obtained

#### Where

W denotes specific wear rates in  $\text{mm}^3/\text{N}$ - delta w is the weight loss measured in grams,

L is the sliding distance in meter density of the worn material in  $\text{g}/\text{mm}^3$  and

F is the applied load in N.

Weight loss of the alloy and composite samples in grams is shown in Table

1. Area:-Cross sectional Area,
2. Volume loss:-Volume loss = Cross sectional Area x Height loss
3. Wear rate:-Wear rate = Volume loss / Sliding distance
4. Wear resistance:-Wear resistance = 1/ Wear rate
5. Specific wear rate:-Specific wear rate = Wear rate/load

Specific wear rate = weight loss/sliding distance \*load \*density

Sliding velocity in m/sec

Weight loss in newtons

Load in newtons

### Density test

Archimedes' Principle aids in the determination of density by providing a convenient and accurate method for determining the volume of an irregularly shaped object, like a rock. This method is quite commonly used in the construction industry. It is known also as Hydrostatic Weighing.

## IV. RESULTS AND DISCUSSION

The below graphs show that comparison of neat vinyl ester with different fillers with their different percentages and specific wear rate. The graph comparison between load vs. specific wear rate, so here loads are 9.81N, 19.62N, 29.43N. As already observe in the tensile and flexural testing if filler content is increased strength will be increased so same as in wear testing also. If filler content increased the wear rate will be decreased. Generally we know loads will increased wear rate will be increased so here also same if load increased the wear rate will be increased. And in case of speed also if speed is increased the specific wear rate will be increased. By observing this graph in case of  $\text{Al}_2\text{O}_3$  filler material at 7.5% having greater wear rate compared to 10% and 12.5%. and  $\text{MoS}_2$  filler also same at 7.5% is having greater wear rate compared to 10% and 12.5%. and last one  $\text{TiO}_2$  is having low specific rate compared to  $\text{Al}_2\text{O}_3$  and  $\text{MoS}_2$  fillers. Over all comparison  $\text{TiO}_2$  filler is having low specific wear rate. Overall discussion by increasing the filler content wear rate will be decreasing and if load increased wear rate will be increased. We can observe in the graph wear rate of without filler and with filler of composite material with filler material filler material is having low wear rate compared to without filler material.

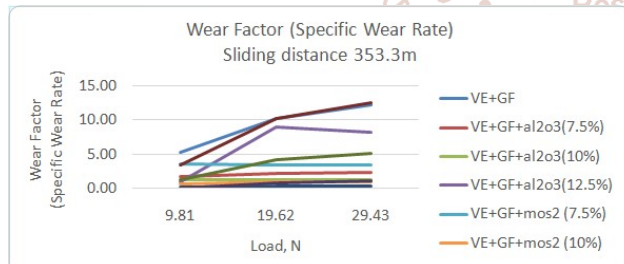
### Figures and Tables



Wear testing machine

| Load, N            | 9.8                              | 20  | 29.4 | 9.8 | 20  | 29  | 9.81 | 19.6 | 29.4 |
|--------------------|----------------------------------|-----|------|-----|-----|-----|------|------|------|
| Sliding Distance   | 353                              | 353 | 353  | 707 | 707 | 707 | 1060 | 1060 | 1060 |
| Sample             | Wear Factor (Specific Wear Rate) |     |      |     |     |     |      |      |      |
| VE+GF              | 5.2                              | 10  | 12.2 | 7.2 | 12  | 13  | 7.82 | 12.3 | 13.8 |
| VE+GF+al2o3(7.5%)  | 1.8                              | 2.3 | 2.4  | 6.5 | 5.7 | 5.4 | 8.06 | 6.79 | 6.36 |
| VE+GF+al2o3(10%)   | 1.3                              | 1.3 | 1.32 | 3.9 | 4.4 | 4.6 | 4.75 | 5.42 | 5.42 |
| VE+GF+al2o3(12.5%) | 1                                | 9   | 8.26 | 2.4 | 3   | 3.2 | 2.59 | 3.72 | 4    |
| VE+GF+mos2(7.5%)   | 3.6                              | 3.5 | 3.45 | 5.5 | 3.9 | 3.4 | 6.2  | 4.08 | 3.37 |
| VE+GF+mos2(10%)    | 0.7                              | 0.9 | 0.93 | 1.3 | 1.3 | 1   | 2.52 | 1.44 | 1.07 |
| VE+GF+mos2(12.5%)  | 0.2                              | 0.3 | 0.37 | 1   | 0.7 | 0.6 | 1.24 | 0.77 | 0.61 |
| VE+GF+TIO2(7.5%)   | 3.5                              | 10  | 12.5 | 12  | 10  | 9.4 | 14.4 | 9.91 | 8.41 |
| VE+GF+TIO2(10%)    | 1.3                              | 4.1 | 5.05 | 5.9 | 4.7 | 4.3 | 7.14 | 4.88 | 4.04 |
| VE+GF+TIO2(12.5%)  | 0                                | 0.9 | 1.16 | 2.2 | 1.7 | 1.5 | 2.9  | 1.99 | 1.66 |

Wear Test Results



Wear factor vs different samples and their different percentages

## V. CONCLUSION

The main aim of this investigation is to investigate the influence of fillers [ $Al_2O_3$ ,  $TiO_2$ ,  $MoS_2$ ] on the dry sliding wear. The following conclusions are drawn from the work

- The wear performances of glass fiber reinforced composites were strongly proportional to the applied load, sliding velocity, distances etc.

- It is found that with an increase in sliding distance, the wear rate is increased.
- The wear volume loss is increased in V-E composites with increase in sliding distance.
- $TiO_2$  filler having a low wear rate compared to  $Al_2O_3$ ,  $MoS_2$  fillers.

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