Mechanical Characterization of Polymer Nano Composites and Evaluation of Tribological Behaviour

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Abstract:
Lubricant property of graphene nano platelets is used for improving the polymer wear properties. Polymer matrix is interpreted in terms of 3 phase module, in which the crystalline phase fluctuates on upon adding Graphane Nano Platelets. Thermal conductivity varies in accordance with the polymer crystallinity Tensile and flexural tests shows the increase in modules and decrease in fracture structure. GNPs are used without any chemicals as a filler material in polymer based materials for improving surface hardness and its Tribological behaviour. And finally these composite surfaces are much improved in hardness with great decrease in the wear property.

Keywords: epoxy, glassfabric, nanographene, tribological behaviour and mechanical characterisation.

I. INTRODUCTION

Nano composites are composite materials having one of the phases with dimension in the nanometer range. Nano composites are possible alternatives to micro composites and monolithic due to their outstanding properties. However, the preparation techniques of nano composites present challenges due to the control of elemental composition and stoichiometry in the nano phase. Additionally, the discovery of carbon nanotubes in 1991 and their use in the fabricating nano composites, added a new interesting feature to this area. Nano composites are materials to which nano sized filler components are added in order to improve the properties of the resulting materials. Nano composites are composed of two or more distinct constituents or phases having different physical and chemical properties and are separated by a distinct interface.

Their unique properties are not depicted by any of the constituents. The constituent that is generally present in greater quantity is called the matrix. The constituent that is embedded into the matrix material in order to improve the mechanical properties of nano composites is called reinforcement. Generally, nano composites show anisotropy (properties are directionally dependent) because of the distinct properties of constituents and inhomogeneous distribution of the reinforcement. Reinforcement is generally in the form of nano sized filler materials. Reinforcement is generally in the form of nano sized filler materials. Nanocomposites are extremely good alternative to conventional composite materials due to their outstanding properties and are finding a wide range of applications in various fields.

Nano composite systems with carbon nanotubes have been a topic of recent research and development since their discovery in 1991 and there has been a steady and continuous increase in number of publications on this topic, including reviews and patents from time to time. Nanocomposites are also found in nature, for example in the structure of the abalone shell and bone. Nanocomposites differ from conventional composites due to high surface area to volume ratio of the reinforcing nanoparticles and their exceptionally high aspect ratio. The reinforcing material can be made up of particles (e.g. minerals, metallic nanoparticles, Carbon nanotubes), sheets (e.g. exfoliated clay stacks, graphene) or fibers (e.g. Electrospun nanofibers). The area of the interface between the matrix and nano-reinforcement is typically an order of magnitude higher than the conventional composites. Clays are a group of nanofiller materials which have been extensively used for the preparation of polymer matrix nanocomposites. Polymer/ clay nanocomposites have been receiving tremendous attention recently in academia and in industries due to their improved properties compared to conventional composites Polymer nanocomposites can be fabricated in a number of ways including in situ polymerization, melt blending, solution mixing and latex methods.

II. OBJECTIVE

Preparation of composite material. Specimen preparation as per ASTM standards. Testing specimens as per standards. Evaluation of tribological properties by sliding wear using pin on disc machine. Evaluation of microstructure of worn surface. Using SQC techniques for data analysis such as taguchi technique. Conduction of two body wear after selecting different grit size to evaluate wear resistant properties.

III. METHODOLOGY

Formulation of different material systems. Selection of manufacturing method for composite. Selection of matrix reinforcement and nano fillers after going through literature survey. Fabrication of composite material. Specimen preparation as per ASTM standards. Testing the specimens as per standards. Evaluation and analysis of the generated data by various tools such as taguchi technique. Evaluation of surface texture of worn surface s by SEM/TEM.
IV. MATERIALS AND FORMULATIONS

1. PURE/NEAT EPOXY

These are used where the application is indoors; away from direct sunlight and where chemical resistance is required. The coating is smooth with no orange peel. Most low gloss finishes are based on this. Epoxy coatings are non-weather able finishes which possess outstanding chemical and mechanical properties. Epoxy Powders are the combination of pure epoxy resins cross-linked with proprietary hardeners. This chemistry of powder coating finds its applications where maximum corrosion and chemical resistance is required.

2. EPOXY WITH GLASS FIBER

3. GLASS EPOXY WITH 1% GRAPHENE

4. GLASS EPOXY WITH 2% GRAPHENE

WEAR TESTING MEASUREMENTS
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.

EXPERIMENTAL PROCEDURE OF WEAR TEST
Dry sliding wear tests for different number of specimens was conducted by using a pin-on-disc machine. In this experiment, the test was conducted with the following parameters:
1. Load
2. Velocity

PIN ON DISC 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. Before the start of each experiment, precautionary steps were taken to make sure that the load was applied in normal direction. Figure 3.1 represents a schematic view of Pin-on-Disc setup.
LOAD VARIABLE DATA ANALYSIS

1. Load V/s Specific wear rate

Table 1. Load V/s Specific wear rate

<table>
<thead>
<tr>
<th>LOAD (N)</th>
<th>EP (mm³/N·m)</th>
<th>GE (mm³/N·m)</th>
<th>GE1 (mm³/N·m)</th>
<th>GE2 (mm³/N·m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>0.09171</td>
<td>0.24725</td>
<td>0.43328</td>
<td>0.54975</td>
</tr>
<tr>
<td>50</td>
<td>0.08647</td>
<td>0.16456</td>
<td>0.31331</td>
<td>0.37044</td>
</tr>
<tr>
<td>75</td>
<td>0.07985</td>
<td>0.12446</td>
<td>0.23295</td>
<td>0.26639</td>
</tr>
<tr>
<td>100</td>
<td>0.05657</td>
<td>0.0954</td>
<td>0.16572</td>
<td>0.19324</td>
</tr>
</tbody>
</table>

Here,
Load is in newton (N).
Specific wear rate in mm³/N·m.

Figure 6. Load V/S Specific Wear Rate

2. Load V/s Wear volume

Table 2. Load V/s wear volume

<table>
<thead>
<tr>
<th>LOAD (N)</th>
<th>EP (mm³)</th>
<th>GE (mm³)</th>
<th>GE1 (mm³)</th>
<th>GE2 (mm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>0.00114</td>
<td>0.00114</td>
<td>0.00151</td>
<td>0.00166</td>
</tr>
<tr>
<td>50</td>
<td>0.0013</td>
<td>0.00156</td>
<td>0.00185</td>
<td>0.00232</td>
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<td>75</td>
<td>0.00144</td>
<td>0.00213</td>
<td>0.00278</td>
<td>0.00303</td>
</tr>
<tr>
<td>100</td>
<td>0.00213</td>
<td>0.00278</td>
<td>0.00333</td>
<td>0.0035</td>
</tr>
</tbody>
</table>

Here,
Load is in newton (N).
Wear volume in mm³.

Figure 7. Load v/s wear volume

V. RESULT & CONCLUSION FOR VARYING LOAD

In the above experimental data we have observed that for a constant velocity and distance with a varying load of 25N, the wear is increasing for higher loads for a pure epoxy. And for GE1 & GE2, i.e., 1% and 2% of graphene added to epoxy, the wear properties will gradually decrease for higher addition of graphene. From the above graph status fig 3.2, we can see that for higher values of graphene content in epoxy composites will have better specific wear rate with higher loads. And from fig 3.3, we can see the change over in wear volume. Hence we can conclude that graphene content can improve wear properties.

3. Velocity V/s Specific Wear rate

Table 3. Velocity V/s Specific wear rate

<table>
<thead>
<tr>
<th>VELOCITY (m/s)</th>
<th>EP (mm³/N·m)</th>
<th>GE (mm³/N·m)</th>
<th>GE1 (mm³/N·m)</th>
<th>GE2 (mm³/N·m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>3.96</td>
<td>3.25</td>
<td>2.904</td>
<td>2.387</td>
</tr>
<tr>
<td>1.0</td>
<td>4.57</td>
<td>3.55</td>
<td>3.1096</td>
<td>2.778</td>
</tr>
<tr>
<td>1.5</td>
<td>5.07</td>
<td>4.28</td>
<td>3.522</td>
<td>3.286</td>
</tr>
<tr>
<td>2.0</td>
<td>6.01</td>
<td>5.78</td>
<td>4.838</td>
<td>3.995</td>
</tr>
</tbody>
</table>

Here,
Velocity is in newton (m/s).
Specific wear rate in mm³/N·m.

Figure 8. velocity v/s sp wear rate

4. Velocity V/s Wear Volume

Table 4. Velocity V/s Wear Volume

<table>
<thead>
<tr>
<th>VELOCITY (m/s)</th>
<th>EP (mm³)</th>
<th>GE (mm³)</th>
<th>GE1 (mm³)</th>
<th>GE2 (mm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>0.41597</td>
<td>0.2187</td>
<td>0.13183</td>
<td>0.0778</td>
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<td>0.43741</td>
<td>0.26366</td>
<td>0.15573</td>
</tr>
<tr>
<td>1.5</td>
<td>1.24792</td>
<td>0.65611</td>
<td>0.39548</td>
<td>0.2336</td>
</tr>
<tr>
<td>2.0</td>
<td>1.66389</td>
<td>0.87481</td>
<td>0.52731</td>
<td>0.31147</td>
</tr>
</tbody>
</table>
VI. RESULT & CONCLUSION FOR VELOCITY VARIABLE

In the above experimental data we have observed that for a constant load and distance with a varying velocity. The wear is increasing for higher speed for a pure epoxy. And for GE1 & GE2 i.e 1% and 2% of graphene added to epoxy the wear properties will gradually decrease for higher addition of graphene. Finally from the observation for higher speeds the wear is more and on adding GNPs it can be advanced to reduce wear.

VII. REFERENCES


