

Characterization of Epoxy Reinforced with Glass Fibre and Cenosphere

Akshay S N¹, Sachin Arakeri², Manoj G S³, Kiran G Hiremath⁴, Sourabh Savadatti⁵, Soumya S Tuppad⁶

U.G. Student, Department of Industrial Production, B V Bhoomaraddi College of Engineering and Technology,
Hubballi, Karnataka, India^{1,2,3,4}

U.G. Student, Department of Instrumentation Technology, B V Bhoomaraddi College of Engineering and Technology,
Hubballi, Karnataka, India^{5,6}

ABSTRACT: combination of two or more materials to form a new material system with improvised material properties like mechanical, thermal, electrical etc. is called a composite material. A mixture of two or more materials (reinforcement, resin, filler, etc.) differing in form of composition on a macro scale produces new material based on various combinations of compositions. The constituents retain their identities, i.e. they do not dissolve or merge into each other, although they act in concert. Normally, the components can be physically identified and exhibit an interface between each other. Artificially produced multiphase materials have properties better than those of conventional materials (metals, ceramics, or polymers).

KEYWORDS: Cenosphere, Epoxy, & Glass fiber.

I. INTRODUCTION

Composites materials, usually prepared by humans, that are a three-dimensional combination of at least two chemically distinct materials (metals, ceramics or polymers), with a distinct interface dividing the components, mixed to generate properties that cannot be achieved by any of the components acting alone. Composites are combinations of two materials in which one of the materials, called the reinforcing phase, is in the form of FIBREs, sheets, or particles, and is embedded in the other materials called the matrix phase. The reinforcing material and the matrix material can be metal, ceramic, or polymer.

In their broadest form, composites are materials consist of two or more constituents. The constituents are combined in such a way that they keep their individual physical phases and are not soluble in each other or not to form a new chemical compound. One constituent is called reinforcing phase and the one in which the reinforcing phase is embedded is termed as matrix. Some natural examples of composites are abundant brick made of clay reinforced with straw, mud wall with bamboo shoots, concrete, concrete reinforced with steel rebar, granite consisting of quartz, mica and feldspar, wood (cellulose FIBREs in lignin matrix), etc

A Composite material can be defined as a combination of two or more materials that results in better properties than those of the individual components used alone. In contrast to metallic alloys, each material retains its separate chemical, physical, and mechanical properties.

The main advantages of composite materials are their high strength and stiffness, combined with low density, when compared to the bulk materials, allowing for a weight reduction in the finished part the reinforcing phase provides the strength and stiffness. In many of the cases, the reinforcement is harder, stronger, and stiffer than the matrix. The reinforcement is usually a FIBRE or a particulate. Particulate composites have dimensions that are approximately equal in all directions. They can be of spherical, platelets, or any other regular or irregular geometry. Particulate composites usually tend to be much weaker and less stiff than continuous-FIBRE composites, but they are usually much less expensive. Particulate reinforced composites usually contain less reinforcement (up to 40 to 50 volume percent) due to processing difficulties and brittleness.

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LITERATURE REVIEW: Polymers make ideal materials as they can be processed easily, possess lightweight, and desirable mechanical properties. It follows, therefore, that high temperature resins are extensively used in aeronautical applications. Two main kinds of polymers are thermosets and thermoplastics. Thermosets have qualities such as a well-bonded three-dimensional molecular structure after curing. They decompose instead of melting on hardening. Merely changing the basic composition of the resin is enough to alter the conditions suitably for curing and determine its other characteristics. They can be retained in a partially cured condition too over prolonged periods of time, rendering Thermosets very flexible. Thus, they are most suited as matrix bases for advanced conditions FIBRE reinforced composites.

Thermo sets find wide ranging applications in the chopped FIBRE composites form particularly when a premixed or molding compound with FIBREs of specific quality and aspect ratio happens to be starting material as in epoxy, polymer and phenolic polyamide resins.

Thermoplastics have one- or two-dimensional molecular structure and they tend to at an elevated temperature and show exaggerated melting point. Another advantage is that the process of softening at elevated temperatures can reversed to regain its properties during cooling, facilitating applications of conventional compress techniques to mould the compounds.

Resins reinforced with thermoplastics now comprised an emerging group of composites. The theme of most experiments in this area to improve the base properties of the resins and extract the greatest functional advantages from them in new avenues, including attempts to replace metals in die-casting processes. In crystalline thermoplastics, the reinforcement affects the morphology to a considerable extent, prompting the reinforcement to empower nucleation. Whenever crystalline or amorphous, these resins possess the facility to alter their creep over an extensive range of temperature. But this range includes the point at which the usage of resins is constrained, and the reinforcement in such systems can increase the failure load as well as creep resistance.

The second phase (or phases) is embedded in the matrix in a discontinuous form. This secondary phase is called dispersed phase. Dispersed phase is usually stronger than the matrix, therefore it is sometimes called reinforcing phase.

FUNCTIONS:

- To reduce the cost and weight of polymer
- To improve the wear resistance of the polymer

- To increase the hardness of polymer by addition of composites.

DESIGN AND CALCULATIONS:

- After preparing the mould of 143*40*10cms as per the ASTM standards, the composition of various materials has to be calculated as follows:
- Mould dimensions = 143*80*10 mm
- Volume of composite: 114.4 cc

$$\rho = \frac{\text{mass}}{\text{volume}}$$

Material	Supplier	Density (g/cc)
Epoxy + Hardener	YUJE Marketing	1.12
Cenosphere	Sarlachem Industries	0.8
Glass Fibre	Riddhi Enterprises	1.2

Table 3.1 Material procurement details

Sample no	Weight of Epoxy resin	Weight of Cenosphere	Glass fiber	Total
1	116grams	44 grams	35 grams	195 grams
2	116grams	48 grams	23 grams	187 grams
3	116grams	52 grams	10 grams	178 grams
Total	348 grams	144 grams	68 grams	560 grams

Table 3.2 Materials quantity estimation

SELECTION OF FACTORS:

- Percentage of glass fibre (% by volume)
The team also kept several factors constant like
- Sliding distance = 2500 metres
- Disc diameter = 130mm.

II. IMPLEMENTATION

After selecting three factors the team plans for conducting after studying various papers and conducting literature survey, the team decided to measure the wear characteristics of the composite so prepared by conducting wear analysis to the composite and studying the effect of major 3 factors

- Sliding velocity (m/s)
 - Load (N)
- a 3 factor 3 level full factorial design and analyse the wear properties
- Number of factors :3
 - Factors: sliding velocity, load, % of (glass fibre + cenosphere)
 - Number of levels: 3
 - Levels: low (-1), medium (0), high (1)
 - Total set of experiments: (level)^{factor} = 3³ = 27
 - Specimen required: 27

FABRICATION:



Fig.1 Hand lay-up technique

Hand lay-up technique is the simplest method of composite processing. The infrastructural requirement for this method is also minimal. The processing steps are quite simple. First of all, a release gel is sprayed on the mold surface to avoid the sticking of polymer to the surface. Thin plastic sheets are used at the top and bottom of the mold plate to get good surface finish of the product. Reinforcement in the form of woven mats or chopped strand mats is cut as per the mold size and placed at the surface of mold after per spex sheet. Then thermosetting polymer in liquid form is mixed thoroughly in suitable proportion with a prescribed hardener (curing agent) and poured onto the surface of mat already placed in the mold. The polymer is uniformly spread with the help of brush. Second layer of mat is then placed on the polymer surface and a roller is moved with a mild pressure on the mat-polymer layer to remove any air trapped as well as the excess polymer present. The process is repeated for each layer of polymer and mat, till the required layers are stacked. After placing the plastic sheet, release gel is sprayed on the inner surface of the top mold plate which is then kept on the stacked layers and the pressure is applied. After curing either at room temperature or at some specific temperature, mold is opened and the developed composite part is taken out and further processed.

PREPARATION OF SAMPLE:

- Weigh the materials separately in containers as mentioned in table 5.2
- Stir the container containing the epoxy resin for 2mins
- Add the weighed glass fibre to the epoxy and stir the composition for few minutes
- After stirring add the weighed cenosphere to the mixture and stir it again
- Allow the mixture to settle down for few minutes
- Add the hardener to mixture and stir the mixture and pour it immediately to mould already being prepared as per standards
- Cover the mould and allow the composite to settle for few hours
- After the composite is prepared, remove it from the mould and cut the sample into required shape of specimens using the wire EDM cutting machine.

Grind the surfaces of testing using grinding wheel and the specimens are ready for testing

TESTING:

Table 6.1 Wear Rate for Sample 1

Sample	Load	Velocity	Wear Rate
S	10	3	30.36
T	10	4	28.41
U	10	5	25.34

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V	20	3	50.76
W	20	4	48.81
X	20	5	54.47
Y	30	3	87.07
Z	30	4	81.0
A1	30	5	85.89

Table 6.2 Wear Rate for Sample 2

Sample	Load	Velocity	Wear Rate
J	10	3	49.52
K	10	4	40.41
L	10	5	48.84
M	20	3	71.50
N	20	4	80.61
O	20	5	85.76
P	30	3	171.61
Q	30	4	101.57
R	30	5	120.57

Table 6.3Wear Rate for Sample

Sample	Load	Velocity	Wear Rate
A	10	3	72.10
B	10	4	77.75
C	10	5	84.02
D	20	3	86.45
E	20	4	95.42
F	20	5	101.49
G	30	3	126.61
H	30	4	140.51
I	30	5	155.61

III. RESULTS AND DISCUSSION

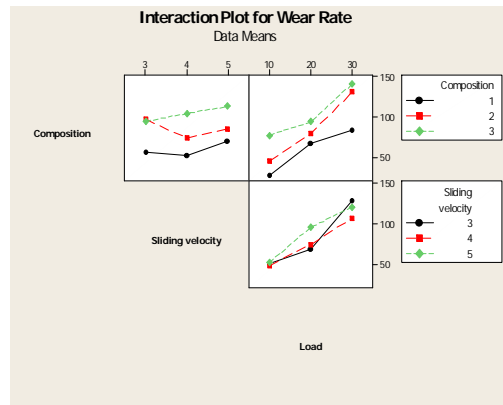


Fig 7.1 Interaction plot

After performing the analysis using MINITAB software, the interaction plot is obtained and following interpretations can be made

- Factors sliding velocity and load show severe interaction between them and their combined effect is more.
- Composition and Load do not have interaction as levels change and hence their combined effect is negligible.
- Composition and Sliding velocity have interaction at low level of velocity (3m/s) and there is no interaction at higher levels.

Individual effect can be studied through main effect plot.

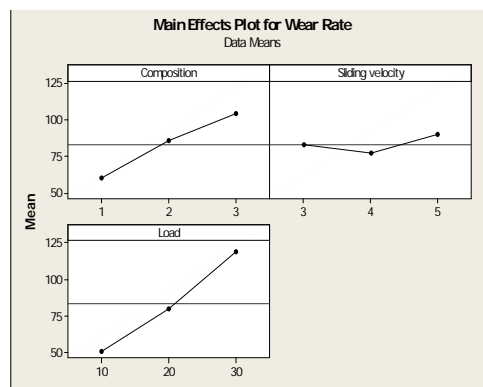


Fig 7.2 Main Effect plot

After studying the individual effects using main effects plot, following interpretations can be made.

- Composition 1 has less wear rate and the wear rate increases for composition 2 and increases further for composition 3, hence composition 1 can be considered ideal as wear rate is less
- Sliding velocity of 4m/s can be selected as this velocity shows less wear when compared to other two velocities as seen in the graph

10N of load shows less wear than other two loads (20N and 30N) and this load can be used to obtain less wear

IV. CONCLUSION

Through the whole process of the experiment, several useful conclusions can be drawn.

- The factors Composition and Load have significant positive effects on the wear rate. Higher load means more wear of the composite.
- From the plot it is observed that both composition and load are the factors that influence the wear rate significantly. In addition, the influence is positive. However, the factor sliding velocity a relatively weak effect on the wear rate.
- The composite is prepared for non-moving bearing application for aerospace engine.
- Composite comprising of epoxy 60%, cenosphere 32% and glass fibre 8% shows low wear rate of 28.41 micrometres working under load of 10N and sliding velocity of 4m/s measured for the total distance of 2500mts.
- Bearings presently used in aerospace engines composing of cenosphere 30% and epoxy 70% experiences wear rate of 67.49 micrometers under working load of 10N can be replaced with the addition of glass fiber as to decrease the wear rate.

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