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Characterization Of Epoxy Composites Reinforced With Short Palmyra Fibers

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ABSTRACT:

Usually a new composite material's performance is often determined by its response under various mechanical, physical, tribological and thermal conditions as it gets very much essential for selecting materials of appropriate composition for application in a particular area. Subsequently, in the present examination, a wealth of property data has been accommodated an arrangement of epoxy-SPF composites by preparing them through hand-lay-up system and via doing different physical, mechanical, tribological, acoustic and warm tests on them under controlled research center conditions. It is watched that by fortifying short palmyra filaments into the flawless epoxy sap, its belongings, as wanted are accomplished as improved mechanical, physical, tribological, warm and acoustic properties. At the point when the centralization of SPF in the slick epoxy is expanded, the particular wear rate diminished slowly and in the meantime a decrease in the compelling warm conductivity is likewise seen as palmyra fiber is insulative in nature. This is joined by increment in both elastic and flexural quality. Further, the sound assimilation coefficient additionally expanded by a tremendous edge as the SPF fixation in the perfect epoxy expanded. The impacts of SPF content on the coefficient of warm development and glass change temperature of the composites are additionally observed to be critical. With a direct quality, diminished wear rate, high coefficient of sound assimilation and brought down warm conductivity, these epoxy-SPF composites can be effectively utilized for applications, for example, building protection material, sustenance compartments, inside of cars, inside mass of lobbies where sound retention in required, canteen flagons, bundling ventures, rollers of transport lines, brake cushions, and so forth.

Key words: *polymer composite; palmyra fiber; dry sliding wear; Taguchi method;*

artificial neural network etc.

I.INTRODUCTION

As the concern over a depleting environment is increasing day-by-day, the need of the hour is to develop such materials which are sustainable and at the same time energy efficient in nature so as to minimize and reduce further damage to an already damaged environment. As a result of this, environment friendly and non-toxic materials are gaining popularity among researchers and industries. Generally, materials developed from agro wastes are considered as environment friendly and bio-degradable materials. These materials are now becoming the centre of attraction because of the numerous advantages offered by them. Apart from providing a clean environment for production, these materials are also inexpensive which further increases the interest of the scientific community to explore the possibilities of using these materials in various application areas. More and more research works are being conducted to study the characteristics and to explore the potential applications of these environment friendly materials. In this context as far as composite materials are concerned, natural fibers are fast emerging as the most promising reinforcing elements with their inexpensive and some excellent properties that otherwise cannot be obtained from synthetic fibers. Now-a-days natural fibers are gradually replacing synthetic fibers in various applications.

II. RESEARCH WORK:

The present research investigation aims to fabricate a new class of fiber reinforced composite material using short palmyra fiber (SPF) as the reinforcing element. The research work is an approach to explore the possibilities of using this new class of

composite material in suitable application areas. The investigation deals with an extensive characterization of the newly developed composite on the basis of its physical, mechanical, micro-structural, wear, thermal and acoustic properties. The effects of addition of SPF on the thermal behavior and acoustic properties have been studied.

The work also uses an optimizing tool in order to minimize the wear rate of the composite and the wear rate within and beyond the experimental domain has been successfully predicted by using Artificial Neural Network (ANN). A predictive equation for estimation of wear rate has also been proposed in this work. Further, the micro-structural features of these composites have been studied using electron microscopy.

III.MATERIALS AND METHODS:

A brief description of experiments and parameters related to the physical, mechanical, micro-structural, tribological, acoustic and thermal behavior of the prepared epoxy-SPF composites.

A composite material essentially consists of two phases in which one is known as the matrix phase and the other is the reinforcing phase. The matrix material forms the base of the composite and is a continuous phase while the reinforcing material is a discontinuous phase which is embedded over the matrix material. The reinforcing phase is usually much harder and stronger as compared to the matrix material. The main purpose of the matrix
material is to provide strength and rigidity to the composite and to transfer the stresses from the reinforcing phase. The matrix material also protects the reinforcing phase from mechanical and environmental damages. Generally, the properties of a composite are much superior to those of its parent constituents.

Mechanical Characterization:

Tensile Strength

The dimension of the specimen used to carry out the test is of 150 mm in length, 20 mm in width and 3 mm in thickness. A uniaxial load is applied at both ends of the specimen. The tests are carried out according to ASTM E 1309 standard. *Instron* 1195 universal testing machine has been used in the present investigation at a crosshead speed of 10 mm/min in order to conduct the experiment. Further, the results are used to calculate the strength of the composite. The test has been conducted on 4 composite samples of each composition and the mean value of the 4 results obtained has been reported as the tensile strength of that specimen.

Flexural Strength

The flexural strength of any material is generally defined as the maximum bending it can withstand before it reaches the breaking point. The present test has been carried out by using *Instron* 1195 universal testing machine following the three point bending method. The dimension of each specimen used is of 60 mm length, 20 mm width and 3 mm thickness with span length of 40 mm. A constant crosshead speed of 10 mm/min is maintained throughout the test. The tests are repeated four times and the mean value of the 4 results obtained is used to calculate the flexural strength.

Micro-hardness

In the present research work, a Vaiseshika micro-hardness tester (Figure 3.12) is used to perform the micro-hardness test. A right pyramid form of diamond indenter with a square base having an angle of 1360 between the opposite faces is forced with a force *F* into the material. The two diagonals *X* and *Y* of the indentation left on the surface of the material after removal of the load are measured and their arithmetic mean *L* is calculated. In the present work, a load of *F* = 0.5 N is applied and the Vickers hardness number is calculated.

IV.TAGUCHI'S EXPERIMENTAL DESIGN FOR SLIDING WEAR TEST

The influence of control factors on the output performance can be successfully analyzed using a very powerful tool known as design-of-experiment. The most critical stage of the design-of-experiment is the selection of the significant factors. Thus, the non-significant factors can be eliminated in the first step itself. In the current investigation of sliding wear rates of epoxy-SPF composites, four major factors have been considered such as fiber
content, normal load, sliding distance and sliding velocity each at 4 levels according to Taguchi's L_{16} orthogonal array as shown in Table 3.4.

Table 3.4: Selected levels of control factors for dry sliding wear test

	Levels				
	1	2	3	4	Units
(A) Sliding velocity	63.0	125.0	190.0	250.0	Cm/sec
(B) Normal load	5.0	10.0	15.0	20.0	N
(C) Sliding distance	250.0	500.0	750.0	1000.0	m
(D) Fiber content	0.0	4.0	8.0	12.0	Wt. %

Acoustic Characterization

Absorbing materials plays a vital role in designing soundproof automobile interior, buildings, studio halls, etc. The extent to which a material can absorb the intensity of sound falling on it is represented by the sound absorption coefficient (α) of the material. The more the sound absorption coefficient, the more will be its soundproofing capacity. In the present study, an impedance tube tester is used to calculate the sound absorption coefficient of the given composite materials as per the ASTM E 1050 standards.

V. PHYSICAL, MECHANICAL AND MICROSTRUCTURAL CHARACTERISTICS OF THE COMPOSITES

Physical Characteristics:

Table 4.1: Theoretical and measured densities of epoxy-SPF composites

SPF Content (wt%)	Theoretical Density (gm/cc)	Measured Density (gm/cc)	Volume Fraction of Voids (%)
0	1.1	1.095	0.454
2	1.098	1.090	0.728
4	1.097	1.085	1.093
6	1.095	1.082	1.187
8	1.094	1.078	1.462
10	1.092	1.072	1.831
12	1.091	1.069	2.016
14	1.089	1.053	3.305

The tensile strengths of the composite specimens are evaluated and the test results for various epoxy-SPF composites are presented in Figure 4.1. It is found that with increase in the SPF content, tensile strength of the composite increases. With a reinforcement of 2 wt% of SPF, the tensile strength of the composite is found to be improved from 65MPa to 78MPa, which indicates an improvement of about 20%. With further addition of the SPF, the tensile strength increases steadily and registers an increment of about 143 % at 14 wt% of SPF content. This can be attributed to the reason that with increase in fiber content, the axial load carrying capacity of the composite improves.

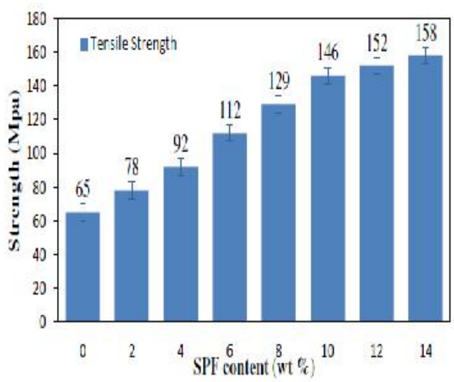

Figure 4.1: Graphical representation of tensile strength

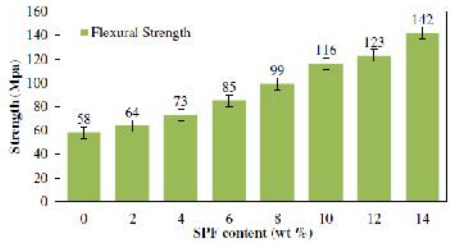

Figure 4.2: Graphical representation of flexural strength

Since composite materials are used in structural applications, they are prone to failure by bending in many situations. So, it is essential to have composites with good resistance to bending. In the present work, the flexural strength values of the epoxy-SPF composites are evaluated and the variations are presented in Figure 4.2.

Micro Hardness:

The wear resistance of any material is dependent on the hardness of that material. In the present research work, the micro-hardness values of the epoxy-SPF composites with different SPF content have been obtained and are presented in Figure 4.3.

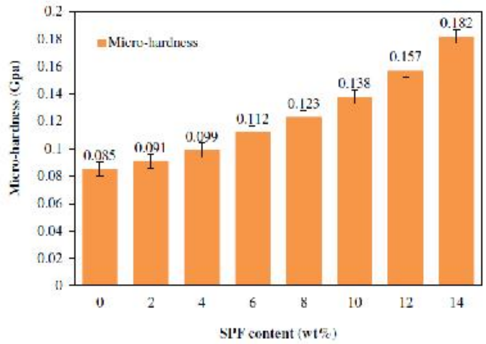

Figure 4.3: Micro-hardness of SPF-epoxy composites

Fourier Transform Infrared Spectroscopy

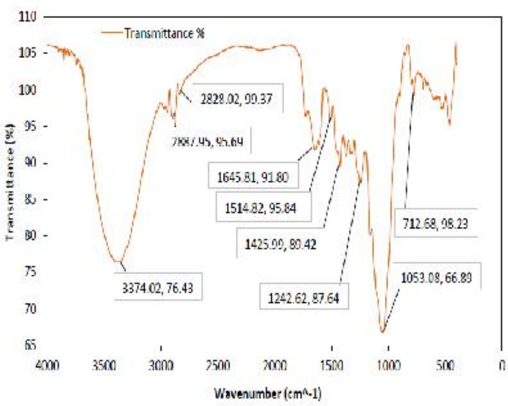

Figure 4.4: FTIR spectroscopy of raw SPF

Analysis and Prediction of Specific Wear Rate Using ANN:

Specific wear rate (10^{-3} mm^3/N-m)			
Test Runs	Experimental Results	ANN Predicted Values	Error %
1	06.360	06.359136	00.013
2	05.469	05.468302	00.012
3	03.625	03.601238	00.655
4	00.917	0.942864	02.820
5	03.856	04.021859	04.301
6	02.332	02.328292	00.159
7	07.818	07.773308	00.571
8	05.823	05.818631	00.075
9	01.444	01.443930	00.004
10	02.828	02.805736	00.787
11	06.430	06.425845	00.064
12	08.818	08.512651	03.462
13	07.469	07.382000	01.520
14	09.481	09.433750	00.529
15	02.666	02.654097	00.446
16	03.656	03.650072	00.111

Acoustic and Thermal Characterization

The acoustic absorption behavior of the epoxy composites under study are analyzed with the help of sound absorption coefficient (ratio of absorbed sound intensity to the initial sound intensity) which is found by using impedance tube test method as per the ASTM E 1050 standards. The values of sound absorption coefficient for any material varies from 0 to 1, where 0 signifies total reflectivity of sound waves and 1 signifies total absorption of the sound waves. In the first set of experiments, the frequency is varied from 125 Hz to 4000 Hz keeping the thickness of the composites constant at 3mm. In the second set of experiments, the frequency is kept constant at 4000 Hz while the thickness is varied from 5 mm to 25 mm and the variation of the sound absorption coefficient is studied. Table 6.1 shows the effects of SPF content on the sound absorption coefficient at varying frequency levels.

Table 6.1: Effect of SPF content on the sound absorption coefficient

SPF Content (wt. %)	Frequency (Hz)							
	125	250	500	1000	1500	2000	3000	4000
2	0.048	0.073	0.112	0.128	0.143	0.168	0.272	0.389
8	0.056	0.088	0.142	0.171	0.180	0.224	0.406	0.503
10	0.069	0.111	0.174	0.231	0.257	0.336	0.524	0.621
14	0.121	0.138	0.236	0.296	0.351	0.476	0.578	0.698

From the Figure 6.1, it is clearly seen that as the fiber content increases from 2 wt. % to 14 wt. %, the sound absorption coefficient also increases.

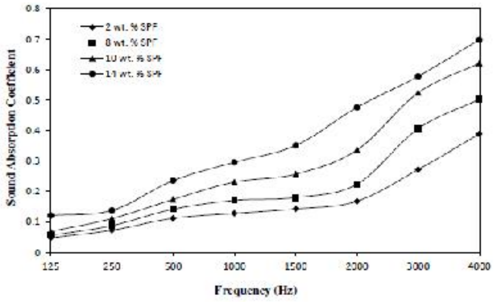

Figure 6.1: Effect of SPF content on sound absorption characteristics

At a frequency of 125 Hz, the sound absorption coefficient of the composite with 2 wt. % fiber is found to be 0.048 which increases to 0.121 for the composite with 14 wt. % of fiber content. Similarly, at 4000 Hz the maximum sound absorption coefficient for the composite with 14 wt. % fiber is found to be 0.698 which suggests that these composites can be successfully used as sound insulating materials.

VI. CONCLUSIONS

This investigation on the processing and characteristics of short palmyra fiber reinforced epoxy composites has led us to the following conclusions:

1. Successful fabrication of epoxy composites reinforced with short palmyra fibers (SPF) is possible through simple hand-lay-up technique.
2. Incorporation of SPF into the neat epoxy has modified its tensile and flexural strength as well as the micro-hardness. It has been observed that with the addition of SPF to neat epoxy, the strength properties improved considerably.
3. FTIR and XRD tests of the samples reveal their molecular orientation and it is concluded that the raw palmyra fiber exhibits about 29% crystallinity indicating its large amorphous nature.
4. Successful analysis of control factors affecting the sliding wear rate is carried out using Taguchi's L16 orthogonal array which is followed by ANN prediction of the specific wear rate within and beyond the scope of experimental data. From the dry sliding wear test results it is observed that the specific wear rate of the epoxy-SPF composites is mostly affected by the fiber content of the samples which is followed by the sliding velocity. The wear rate of the sample is found to be least at 12 wt. % of SPF content and 63 cm/sec of sliding velocity.

VII.REFERENCES

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