EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES AND ELECTRICAL CONDUCTIVITY OF NATURAL FIBRE REINFORCED COMPOSITE

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ABSTRACT

Composites are the most advanced and adoptable materials among all the engineering materials. The natural composites have advantages like low cost, biodegradable nature, recyclable etc. In this present work an attempt is made to develop a new composite material reinforced with natural fibre. Sheep hair mat and epoxy resin is used as reinforcement and matrix respectively in this research work. Hand lay-up process is followed with closed mould technique to produce the specimen. The volumetric ratio of 60:40 i.e. fibre to resin respectively is used for specimen preparation. To enhance the electrical properties of the specimen an aluminium powder is mixed with epoxy resin with the percentages variation of 0%, 10%, 20%, and 25%. The specimens are cut to the required dimensions and subjected to various mechanical and electrical characterizations. The result reveals that, the new composite has the good mechanical properties and offers the high resistance to flow of electricity. Also, it can be conclude that the tensile and hardness strength of wool based composite increases with the addition of aluminium metal powder. But, the compression and bending strength decreases with the addition of aluminium powder. Also, the wool based epoxy acts as bad electrical conductor and this property remains unchanged with the addition of aluminium powder up to 25% by its weight. Thus, an Epoxy composite enforced with sheep wool fibre can be used as insulator in production of electric circuit boards and other industrial applications.

Keyword: *Sheep Wool mat, Aluminium powder, Epoxy resin, Shore-D.*

1. INTRODUCTION

Among engineering materials composites are the most advanced and adoptable materials in the present situation. Focus has shifted towards the natural fibre reinforcement because of its advantageous characteristics from past one decade. Development and research work is been progressively carrying on natural fibre reinforced composites for both fundamental and industrial applications. The natural fibre reinforced composites have advantages like low cost, biodegradable nature can be partially recyclable and renewable. As a source of natural fibre, plants like cotton, bamboo, jute, hemp, wood etc, are used. The natural fibre obtained from the above mentioned sources are environmental friendly and can be used in transportation application such as railway coaches, automobiles, aerospace etc. Packaging, military application, building construction (ceiling, paneling and partition boards), industrial construction are the other area of applications for natural fibre composites. The natural fibres are extracted from the plants, animals and mineral sources. Examples of animal fibre are wool, human hair, feather, etc. Wool has some superior qualities that make it to differ from other natural fibre like hair or feather.

From the past several decades sustainability becomes the major issue in construction which should be eco-friendly and cost effective [1]. The main advantage of using this natural fibre is to overcome from the ecological problem of composite material disposal and recycling [2]. From the survey done it has found that, around 270,000 tons of sheep

wool will be produced from 90 million sheep's in which, 10% is low grade wool and is disposing by some methods. Presently this low grade wool is been utilizing in cement and in mortar of lime based mixtures for well surface rendering. The mortars with sheep wool have better mechanical properties and workability [1]. With the addition of wool and respective compatibilizer a significant increase in the mechanical properties of composite can be achieved like tensile modulus, strength etc [3]. It has found that the thermal conductivity property will get increased with the addition of the sheep wool to the cement. Also the chemical stability with alkalis can be achieved with wool addition to the cement [1]. The composite with combination of 20% goat hair fibre and 80% polyester matrix gives the better results like compressive, tensile and flexural strength as compared with other composites. The impact strength for composite with 15% fibre and 75% polyester is better [4]. In natural composite as the fibre content in the composite decreases, it results in the decrease in dielectric constant [5]. It has investigated that, natural Composites with 40% fibre have the good properties [6].

In this present work, an attempt is made to study the mechanical and electrical properties of natural fiber i.e. sheep wool fiber reinforced epoxy composite. As the additive aluminium powder is added to the mixture to enhance the electrical properties of the natural composite, the respective effect of aluminium powder on the other properties of composites are been studied.

2. DEVELOPMENT OF COMPOSITE

The weight fraction of 60:40 for the preparation of composite was considered i.e. 60% of reinforcement and 40% of epoxy. The addition of aluminum powder as restricted to 0%, 10%, 20% and 25% to the mixture by its weight. The composite specimen was fabricated using manual hand layup technique.

2.1 Material Selection

Mainly the 3 individual constituents were used for the development of composite i.e. sheep wool fiber as reinforcement, epoxy resin as matrix and aluminium metal powder as additive. Wool is the natural fiber obtained from animals like sheep, goat etc. Sheep wool in the form of mat of thickness 1.4 mm was selected as the reinforcement to the resulting composite. The density of the sheep wool is found to be 45 kg/m^3. Figure (1) shows the wool in the form of mat.

Fig-1. Sheep Wool Mat

Fig-2. Epoxy Resin (L-12)

Fig-3. Aluminium Powder

Epoxy resin i.e. Lapox-12 was chosen as the binding phase having the density of 2250 kg/m^3 with the respective k-6 catalyst. The main properties of epoxy resin are excellent adhesion to different materials. To enhance the electrical conducting behavior of the epoxy–wool composite an aluminium metallic powder was chosen as additive. The metal powder is having the density of 705 kg/m^3 and atomic weight of 26.98. The size of aluminium powder may vary from 5 micron-1000 microns. The additive was decided to add to the mixture with the varying percentage of 0%, 10%, 20% and 25% by its weight. Figure (2) and (3) shows the epoxy resin and aluminium powder.

2.2. Composite Fabrication

Hand lay-up process was employed to fabricate the specimen in close mould. Keeping the ASTM testing standards into consideration the volume of specimen was decided as 220×270×5 mm^3 with some allowances. Before stating of the layup process for the preparation of composite, the mould was cleaned and polished well and releaser was applied. As per the dimension of mould the wool mat is cut and numbers of layers are prepared as per the calculations i.e. 3 layers for each specimen. The matrix mixture is prepared with the proper mixing of resin and catalyst with specified ratio. To improve the electrical properties, aluminium powder is added to the matrix mixture with varying percentage of 0%, 10%, 20% and 25% with proper stirring. Then after the laying of alternative mat and epoxy process was carried till the achievement of required thickness of sample. Figure(4) and (5) shows the laying up process and specimen after curing.

Fig-4. Hand Lay-up Process

Fig-5. Fabricated Specimen

2.3. Experimental Procedure

The composite specimen prepared with the reinforcement of wool fibre, undergone certain mechanical and electrical characterization. The mechanical characterizations such as tensile, compression, bending and hardness were carried. The specimen is also tested for its capacity to conduct the electricity. Respective ASTM standards were followed to carry the individual mechanical characterization. Tensile test were carried on Universal testing machine having the capacity of 40 tonne. The standard test procedure was followed and the atmospheric temperature was 30ºC. Figure 6(a) shows the test sample for tensile testing.

Fig-6(a). Tensile Test Samples

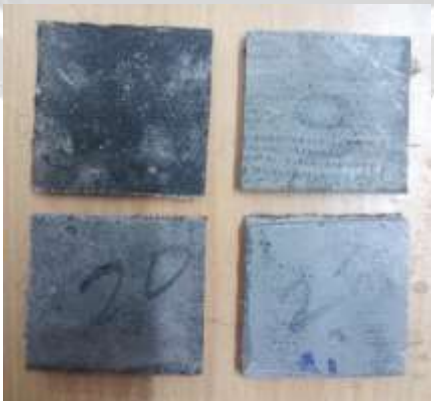

Fig-6(b). Compression Test Samples

Fig-6(c). Bending Test Samples

Similarly, the compression and three point bending tests referring the ASTM D-790 standard were carried on the same UTM machine. The atmospheric condition during the experimentation was same and the respective standard procedure was followed. Figure 6(b) and 6(c) shows the test specimen for compression and bending test respectively. The shore-durometer is used to determine the hardness of the prepared specimens. During the experiment, the indenter or pointer is pressed against the surface of specimen. The indenter penetrates into the specimen and pointer on the analog scale shows the reading of hardness. Figure (7) shows the hardness testing using Shore-D Indicator.

To conduct the electrical conductivity experiment the proper setup was made. The setup involves the ammeter and voltmeter, which are in series with the circuit. The circuits with all the components and specimen are connected in series and flow is given through the 12volts DC battery. The current and voltage readings are noted to find the resistivity and conductivity of specimen. Figure (8) shows the electrical conductivity test setup. Resistivity of sample is given by

$$\rho = \frac{R \times A}{L}$$

Where, R is resistance of material in ohm, A is c/s area of specimen in m^2 and L is the length of specimen in m

Thus, conductivity of the material is given by

$$\sigma = \frac{1}{\rho}$$

Fig-7. Shore-D Testing

Fig-8. Experimental Setup for Electrical Conductivity Test

3. RESULTS AND DISCUSSION

From the experimentation made on tensile characteristics, it can be observed that the tensile strength increases with an increase in the addition of the aluminum powder to the mixture. This increase in tensile property may due to the additional particle reinforcement. The composite without aluminum has a tensile strength of 17.6Mpa, with the addition of 25% of aluminum to mixture the tensile strength increases to 25.86Mpa. Chart (1) illustrates the comparison of strength between resulting 4 specimens having different composition of fibre, epoxy and aluminium. The behavior of elongation enhances with an addition of aluminum powder to the mixture up to 20%, there after increasing the percentage of aluminum decreases the elastic behavior of the composite. The percentage elongation for pure composite is 6.4% and it increases to 11.6% with addition of 20% aluminum to the mixture and then after it again decreases to 6.7% with addition of 25% aluminum. Chart (2) describes the stress versus strain behavior for four different compositions.

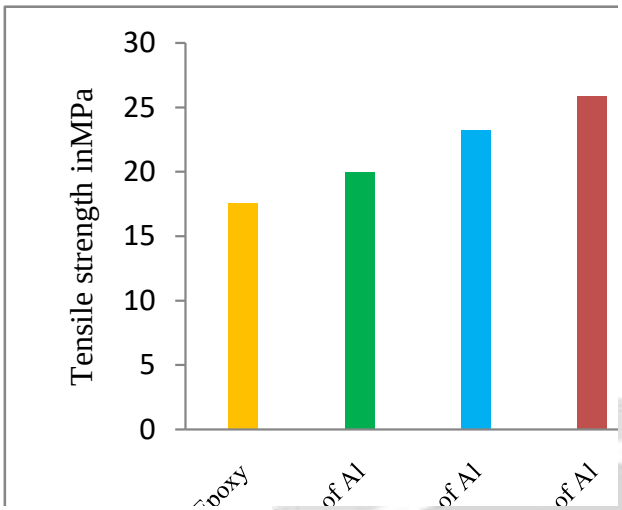

Chart-1 Comparison of Tensile Strength

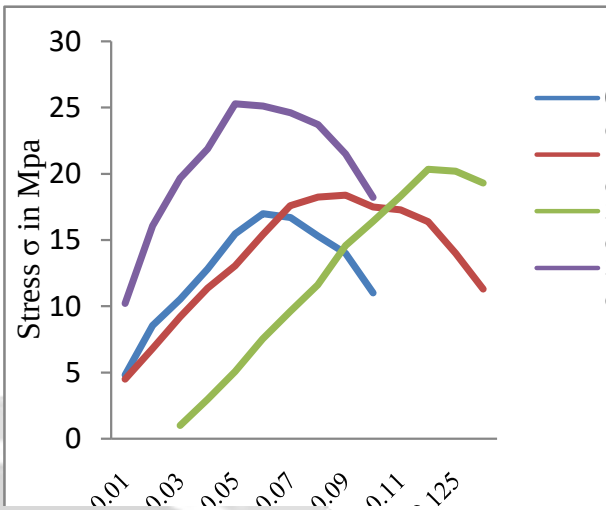

Chart-2. Tensile Stress vs Strain Curve

Chart (3) gives the compression strength comparison between four different resulting composites. From the experimental data of compression test it has observed that the compression strength of the specimen gradually decrease with the increase in the content of aluminium powder into the composite mixture. This reduction in compression behavior may be due to the bonding strength reduction of the addition of aluminium to the matrix. Chart (4) illustrates the stress versus strain behavior during compression test.

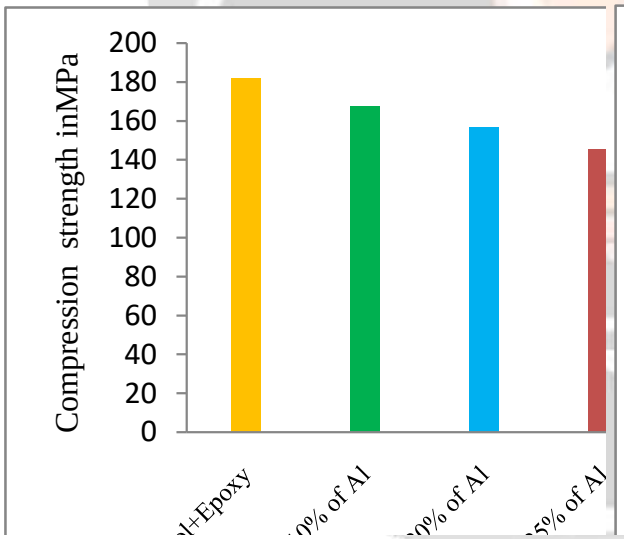

Chart-3. Comparison of Compression Strength

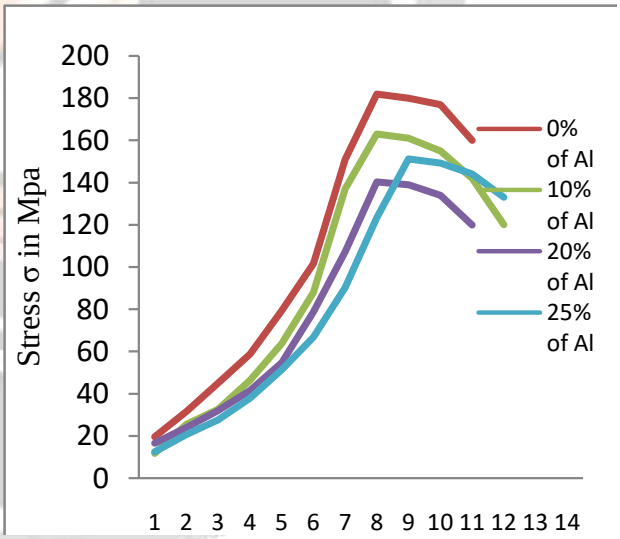

Chart-4. Compression Stress vs. Strain Curve

Chart (5) gives the comparative results of bending strength between the different resulting composites. As shown in the chart, the bending strength of specimen decreases with the increase in percentage of aluminium to the composite mixture.

Based on the hardness results obtained, it can be concluded that, the hardness behavior of specimen increases with increase in the volume of aluminium powder into the entire volume of specimen. The pure specimen without aluminium powder has a hardness of 66.8, the hardness number of specimen increase to 72.6, 71.53 and 72 with the addition of aluminium powder by mass fraction of 10%, 20% and 25% to the mixture respectively. After addition of aluminium powder the specimen becomes brittle, thus resulting in improved hardness behavior of the specimen. Hardness for four different compositions is shown in the bar chart (6).

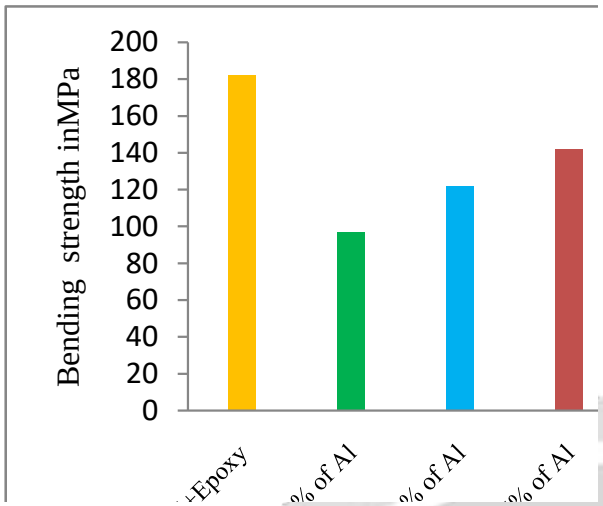

Chart-5. Comparison of bending strength

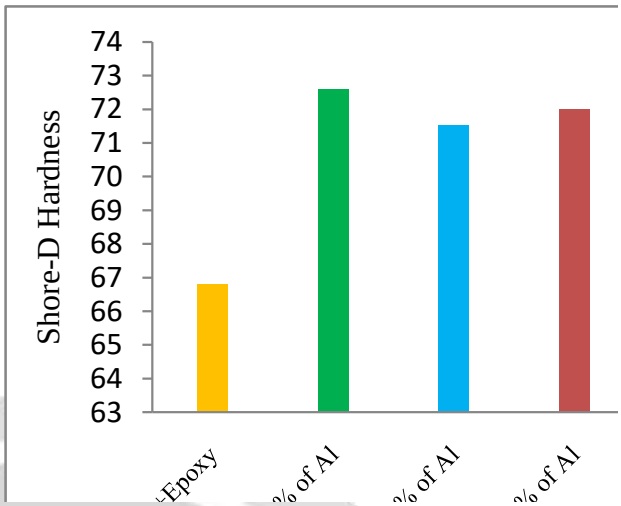

Chart-6. Comparison of bending strength

The experimentation on electrical conductivity of specimen reveals that, electrical conductivity of the composite of sheep wool reinforcement is negligible and acts as insulator. This insulating property of specimen can be employed in production of electrical circuit boards.

Table-1. Strength Comparison of Natural Fibers Reinforced Composites [7]

Sl. No.	properties	Wool and Epoxy				Ukam	Banana	Sisal
		0%Al	10%Al	20%Al	20%Al			
1	Tensile Strength in MPa	17.6	19.94	23.25	25.86	16.25	6.50	5.40
2	Compressive Strength in MPa	182	167.33	156.66	145.2	39.25	16.75	42

Table (1) reflects the comparison between various strengths of sheep wool enforced composite material to that of other natural fibre composites. As per the comparisons made, the sheep wool reinforced epoxy composite material posses good compressive, bending and hardness properties that of other natural composites such as sisal, jute and banana based composites.

4. CONCLUSIONS

From the experimental results obtained and the comparisons made, it can be concluded that the sheep wool reinforced epoxy composite material posses good compressive, bending and hardness properties as compared with that of other natural composites such as sisal, jute and banana. It has also found that, tensile strength and hardness of the specimen increases with increase in percentage addition of aluminium powder to the mixture up to 25% by its weight. Also, the compression and bending properties of the wool epoxy based composite decreases with increase in the percentage addition of aluminium powder. The wool enforced epoxy composite acts as electrical insulator and there is no noticeable influence of addition of aluminium metal powder to the mixture on the electrical conductance of specimen. An epoxy composite reinforced with sheep wool fibre and Aluminium metal powder possesses good mechanical properties and offer resistance to flow of electricity. Thus, this composite can be applicable in electrical circuit boards and other applications where the insulation is the main requirement.

5. REFERENCES

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