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Hardness and Electrical Properties of Pine Cone Reinforced Polymer Composite

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Abstract

This article presents a novel study of development and testing of electrically conductive polymer composite. Pine cone fibres were used as a reinforcement in an epoxy matrix and pre-designated composite specimens were fabricated. The developed composite was modified with the incorporation of graphite micro powder in the matrix. Hardness and Electrical conductivity of the developed polymer specimens were evaluated. Maximum hardness with fibre was achieved at 10% weight fraction and further decreased with increase in fibre loading where as in addition of graphite with the composition samples the hardness is substantially increasing up to 123HRC. Maximum electrical conductivity was obtained for 6% graphite loading.

Keywords: *Graphite; Pine Cone; Epoxy; Electrical Conductivity.*

Introduction

From the past many years, fire outbreak and rate of spread were dominantly affected by Pines Roxburghii (pine cone) in northern India [1, 2]. Forest fire annihilating behavior not only effect the vegetation but devastate the entire flora and fauna of geographic region. The burgeon of awareness on forest fuel in spreading of fire leads to the dawn of numerous solution [3]**.** One of such kernelsof idea is to make use of these dried pines to develop composite materials for the non-structural application. These days, forest wastes are either parched or even better, some different high endues is found [4]. Kanishka Jha et al. studied the mechanical and wear properties of E-glass/jute-reinforced hybrid composite. The composite samples were fabricated by combination of handlay-up and compression technique. It was found that the composite showed a better increment in the mechanical properties. There was the increment of tensile properties by 150%. From the experiment, it is concluded that the jute fibre showed better improved even though when they are clubbed with E-glass fibre their properties were enhanced .so it indicates that the combining E glass fibre results in better and improved wear resistance. With increment in the jute weight percentage lead to less wear rate than higher e-glass weight percentage.[5]Yucheng Liu et al. prepared and evaluated the morphological properties of corn stalk fibre reinforced by silane solution. The experiment showed a low-density property. water absorption and porosity of the polymer composite property was reduced. The silane treatment didn’t improve the friction property but effectively improved the wear rate of the composite.

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Wear rate was reduced by 5% as compared with raw corn stalk fibre to reinforced corn stalk fibre[6]. Goutham Reddy et al. worked to see the consequence of cavities in the fibre-reinforced polymer composites. hand moulding process is preferred for the fabricating the samples as per ASTM D638.few samples were free of voids and few with voids in the composites.at the time of fabricating the fibre reinforced composites, the water-soaked gel globules of different dimensions ½ mm to 2 mm were placed at the middle of the specimen. Later voids are created because the water-soaked gel balls are dried and they dimensions are reduced to 1/10 mm.by the way voids were created in the composites. A later tensile test is conducted on both the samples which are with voids and without voids. The samples with void had less tensile strength than the sample which did not have voids. From this experiment it is concluded that if voids are created at the time of fabrication or the crack are formed earlier which make leads to the decrement in the mechanical properties of the composite[7]. P.J. Herrera-Franco et al. studied the mechanical properties of continuous henequen fibre reinforced in high-density polyethene. Fiber matrix adhesion was increased by modifying with alkaline treatment with silane agent. Silane coupling agent increased the fibre-matrix interaction. It was also found that the mechanical properties, it was found that the mechanical properties did not improve when high silane concentration was used to treat the fibre surface. the increment in the mechanical properties was ranged between 3% to 43% for longitudinal and for the transverse tensile and flexural strength increased by around 50%.[8]

Experimentation

Fibres and whiskers in composites are held together by a cover known as Matrix. The resistance of the polymer matrix composite is decided by properties of matrix. If the properties are not compatible then it leads to delamination, impact damage, chemical attack water absorption, and high-temperature creep. Thus, the weak link in a Polymer matrix composites structure is a matrix. Reinforced plastics, and advanced composites are the two classification of polymer matrix composite. Both types are different from their mechanical properties. Reinforced plastics mainly consist of resins generally reinforced with glass fibres of low-stiffness values. Advanced Composites consist of different fibres and a combination of matrix that gives superior strength and stiffness. The Polymer matrix composites are designed and manufactured so that the loads are bearded by the reinforcements. The important purpose of the matrix is to distribute the load and hold the fibers together.

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(a) (b) (c)

Figure 1 (a) Pine Cone Fiber, (b) Epoxy Resin and (c) Hardener

The polymer matrix is of two type, thermosets and thermoplastics. Thermoset polymer opts for work. epoxy, vinyl ester, polyester and phenolic are thermosets. The uncured epoxy does not possess better thermal and mechanical properties. After mixing the epoxy and fiber better properties are obtained. Firstly, the linear epoxy is converted to 3-dimensional thermoset structure by the process curing. Curing method of epoxy resins is an exothermic phenomenon and, in a few cases, it produces sufficient heat to cause thermal degradation of specimens if not controlled [9]. Epoxy AY-105 is used as matrix. Epoxy has the lap shear and viscosity at 25°C, 12.63 MPa and 11345 MPa correspondingly. At room temperature the density of epoxy was found to be calculated 1.109 g/cm3. The curing agent HY-951 is used with epoxy. The hardener and epoxy had purchased from local supplier. Figure 1 shows pine cone fibre, epoxy AY-105, hardener HY-951.

Reinforcement and Matrix Material

The fibres selected for this work was green and biodegradable in nature and taken into a study because of comparatively less quanta of research has been undertaken on this fiber less and the composites are fabricated. The natural fibres are eco-friendly, easily available and can be easily harvested, hence less cost for manufacturing as in artificial fibres and no pollution produced. No health hazard by using natural fibres.

Natural Fiber

The fibres that are commonly available and applicable within PMCs include graphite and fibre-glass etc. Fibre-glass possesses a low stiffness at the same time exhibits a competitive tensile strength as compared to other fibres. The natural fibres are eco-friendly in nature and easily available all over the world. Fibres can be easily harvested so the is no manufacturing cost and fibres do not create pollution. There is no health hazard with the use of natural fibres. Pinecone fibre is used in our study. Pinecone is available in hilly areas in Himachal and is collected and fibre is extracted by crushing the pine cone and removing the fibre from

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the capsule-like leaf [10].

Pine Cone Fiber

Pinecone fibres are a cellulosic material easily available and can be used as reinforcement in a thermoplastic-based composite.

- Pinecone fibre is completely bio-degradable and recyclable and thus environmentally friendly.
- It has a density of 0.6138 g/cm^3 and has good tensile properties.
- As the fibre is extracted from a plant which is available all around the year it is easily available it costs less.

Matrix Modifier

To increase the fibre-matrix interaction or adhesion bonding between them graphite is used as a modifier.

Figure 2 Graphite powder of 120 Micron size

Graphite powder by Loba Chemicals. Its specifications are:

Table 1: Chemical content of Graphite powder

Appearance	**Black Amorphous Powder**
Carbon	Min. 98%
Iron	Max. 0.4%
Sulphur	Max. 0.1%
Phosphorus	Traces
Ash Content	Max. 0.5%

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Particle Size	-60 Mesh

Hardness test

Hardness is a measure of material ‘s resistance to permanent deformation or damage. Wear resistance of the material was majorly governed by the surface properties like Hardness. In the present discussion, a Rockwell hardness equipment is used to measure the hardness values of the composite samples in accordance with ASTM D785 test standards. During the test a minor load of 10 kilogram followed by a major loading of 100 kilogram were applied onto the smooth and even surface of the samples. The hardnessmeasured by the depth of indentation

Figure 3 Hardness tester

Electrical Conductive Test

The electrical conductive test is carried out for four different specimens by using the multimeter to find the resistivity which is inverse of conductivity as the resistivity depends on dimensions of specimen they are ensured to be made identical.

Conductivity can be calculated through resistivity

Resistivity $\rho = \frac{RA}{L}$

Where, ρ = resistivity

R = resistance

A = cross-sectional area

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L = length

Conductivity, K = $\frac{1}{\rho}$

As conductivity is reciprocal of resistivity.

Results and Discussion

The effect of pinecone fiber content on the hardness of the hybrid reinforced epoxy composites is presented in Figure 1 and 2. The hardness of epoxy reinforced with 8 wt.% pinecone fibers was increased from 107 to 109 Rockwell hardness H relative to the 6wt% pinecone fiber. This remarkable increment in hardness is due to proper distribution of the load on to the fibers, which limits the penetration of the test ball on to the surface of the composite material and consequently lifting the hardness of composite material [11-14]. The hardness no. increases by increasing the fiber loading, reason for the is the fact that pine cone fiber is having comparatively higher density, better bonding and consistency of the matrix with better wettability among the fibers and the matrix.

Table 2: Summary of hardness test results of developed composites

Composites without graphite	Rockwell hardness	Composites with graphite	Rockwell hardness
P6	107	**P12G2**	117.666
P8	109	**P12G4**	119
P10	111.66	**P12G6**	120
P12	103	**P12G8**	123

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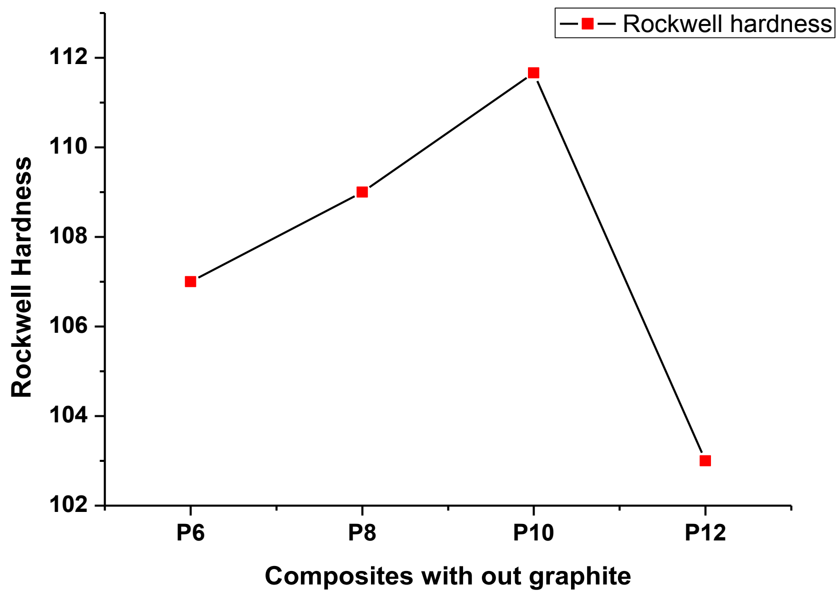

Figure 1: Rockwell Hardness without graphite

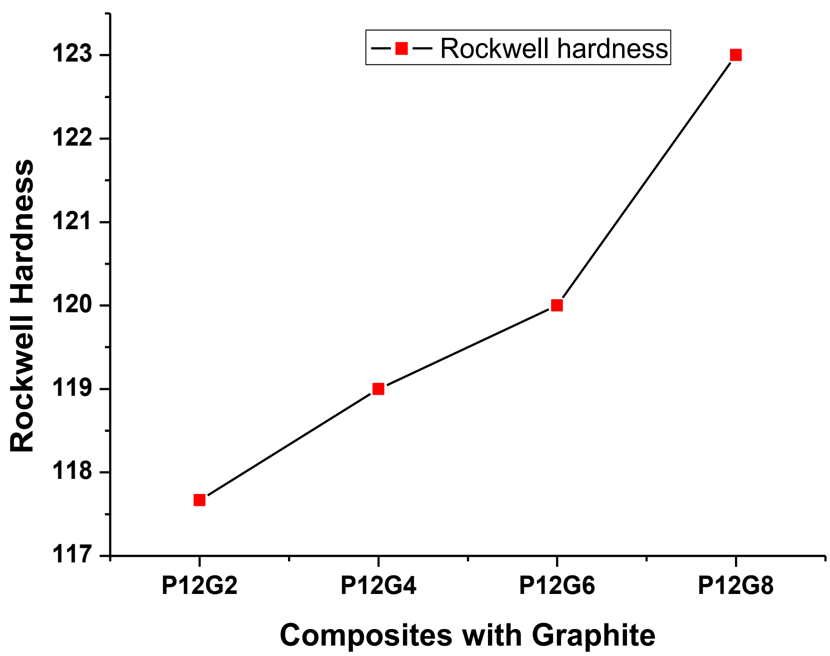

Figure 2: Rockwell hardness with graphite

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Electrically conductivity test

To make the composite electrically conductive we modified the composite with graphite matrix modifier and tested the resistance of the composite with multimeter and found the conductance. In this with increase in graphite % the conductivity of the composite increased but with the limit exceeding the threshold limit the properties start to degrade at a % of 8 by weight [15].

Composite composition	**Evaluated Conductivity**(S/cm)
P12G2	$3.0 * 10^{-7}$
P12G4	$5.2 * 10^{-7}$
P12G6	$5.5*10^{-7}$
P12G8	$2.8 * 10^{-7}$

Conclusion

Environment is getting badly polluted everyday due to extensive usage of man-made fiber that are synthetic as reinforcement for natural fiber polymer composite.in this study we worked with natural fiber as reinforcement material we used fiber extracted from pine cone to reinforce the composite. In this work we study characteristics of the composites with and without modifying the composites with graphite.

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