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Water Absorption and Compressive Properties of Coconut Shell Particle Reinforced-Epoxy Composite

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Abstract

The Aim of present investigations is to evaluate the physical property-water absorptions and mechanical property-compressive properties. Coconut particle reinforced composites were fabricated by reinforcing shell particle (size between 200-800μm) by wt% of 20, 25, 30 & 35 into epoxy matrix. Composites plates were made by casting in open mould. That is possible with very low cost and easy way. Experimental results showed that water absorption increases with the increase of wt% of particle but compressive properties increases upto 30wt% of particle approaches to actual compressive strength of epoxy.

Keywords: Coconut particle, particle board, water absorption, compressive strength

1. Introduction

Composites consist of one or more discontinuous phases embedded in a continuous phase. The discontinuous phase is usually harder and stronger than the continuous phase and is called the 'reinforcement' or 'reinforcing material', whereas the continuous phase is termed as the 'matrix'. Properties of composites are strongly dependent on the properties of their constituent materials, their distribution and the interaction among them. The geometry of the reinforcement (shape, size and size distribution) influences the properties of the composite to a great extent.

Natural fillers and fibers reinforced thermoplastic composite have successfully proven their high qualities in various fields of technical application. As replacements for conventional synthetic fibers like aramid and glass fibers are increasingly used for reinforcement in the thermoplastic due to their low density, good thermal insulation and mechanical properties, reduced tool wear, unlimited availability, low price, and problem free disposal. Wood fibers/particles provide a sufficient reinforcement at much lower cost than synthetic and mineral filled thermoplastic. When synthetic and mineral fibres are used, machine wear and damage of processing equipment is much higher than with wood filler. Fiber damage during processing is greatly reduced when wood is utilized, which allows for recycling production waste without compromising quality [1].

Luo and Netravali [2], Ahmed [3], Faud [4] and Schneider [5] studied pineapple, filament wound cotton fibre, oil palm wood flour and jute & kenaf fiber based composite respectively.

In general, particles are not very effective in improving fracture resistance but they enhance the stiffness of the composite to a limited extent. Particle fillers are widely used to improve the properties of matrix materials such as to modify the thermal and electrical conductivities. Particles improve performance at elevated temperatures, reduce friction, increase wear and abrasion resistance, improve machinability, increase surface hardness and reduce shrinkage. Particles are more commonly used as extenders to lower the polymer use with other simultaneous improvement in properties.

Coconut shell is one of the most important natural fillers produced in tropical countries like Malaysia, Indonesia, Thailand, Sri Lanka and India. Many works have been devoted to use of other natural fillers in composite in recent past and coconut shell filler is a potential candidate for the development of new composites because of their high strength and modulus properties. The coconut particles also have remarkable interest in the automotive industry owing to its hard-wearing quality and high hardness (not fragile like glass fiber), good acoustic resistance, moth-proof, not toxic, resistant to microbial and fungi degradation, and not easily combustible.

Composite of coconut fillers with high compressive strength can be used in broad range of applications of load bearing. The aim of this paper is to investigate the water absorptions and compressive strength based coconut shell filler particles composite.

2. Materials and methods

2.1 Materials

2.1.1 COCONUT SHELL PARTICLE

Coconut shell particles are used as reinforcing material for investigation. Shell particles of size between 200-800μm are prepared in grinding machine. Coconut shell filler are potential candidates for the development of new composites because of their high strength and modulus properties. An approximate value of coconut shell density is 1.60 g/cm^3.

Figure 1: Coconut Shell

Figure 2: Coconut shell Particles

2.1.2 EPOXY RESIN

Epoxy resins are one of the most important classes of thermosetting polymers which are widely used as matrices for fiber-reinforced composite materials and as structural adhesives [1-6]. They are amorphous, highly cross linked polymers and this structure results in these materials possessing various desirable properties such as high tensile strength and modulus, uncomplicated processing, good thermal and chemical resistance, and dimensional stability [1]. However, it leads to low toughness and poor crack resistance, which should be upgraded before they can be considered many end-use applications [1, 2].

In the present investigation epoxy resin SY-12(319) purchased from M/s RESINOVA CHEMIE Limited, Kanpur India has been used as matrix material. The epoxy used is colourless, odorless and completely nontoxic. Tensile, modulus of elasticity compressive, flexural, and impact strengths are 43 MPa, 800-820 kg/mm^2, 90-100 MPa, 50-60 MPa, 2.5-4 kg-cm/cm^2 respectively. Density is 1.15 g/cm^3.

2.1.3 Hardener

Hardener SY31(B) is a yellowish-green liquid. Hardener SY31(B) purchased from M/s RESINOVA CHEMIE Limited, Kanpur, India has been used as curing agent. In the present investigation 8 % wt/wt has been used in all material developed. Specific viscosity of hardener is 10-20 cps. The weight percentage of hardener used in the present investigation is as per recommendation of Singh V.K. [6].

2.2 Method

2.2.1 COMPOSITE FABRICATION

The measured quantity of resin and coconut shell particle is mixed according to required 20wt%, 25wt%, 30wt% and 35wt% is kept in the furnace at a temperature of 90 ± 10 $^{\circ}$C for two hours as per the recommendation of Singh V.K. [10]. The electric furnace (Temperature Range 0-600^{0}C) used for this purpose. At each interval of 30 minutes the solution have been taken out from the furnace and remixed by mechanical stirrer at high speed. After two hours the whole solution is taken out and allowed to cool to a temperature of 45°C. When a temperature of 45°C has been attained 8 wt% of the hardener is mixed immediately. Due to addition of hardener high viscous solution has been obtained which is again mixed mechanically by high speed mechanical stirrer. The viscous solution so obtained is poured in to different moulds for sample preparation for tensile testing. The viscous solution obtained from resin, hardener and filler materials is poured in to different moulds as shown in figure 3 for specimen preparation for water absorption and compression testing. Flat plates as required for compression test.

Figure 3: Mould for plate casting

2.2.2 WATER ABSORPTION TEST

Weight of the specimen of sized (15 mm*10 mm*10 mm) were taken then dipped the specimen in to water for 24 hours. After 24 hrs again weights were taken, the difference between weight of specimen before and after the absorption indicates the water absorption capacity of the casting as shown in figure 4.

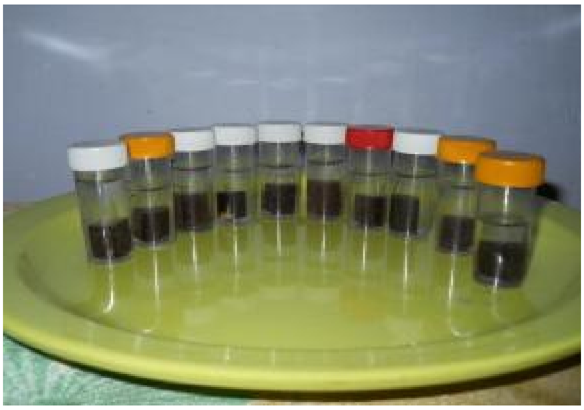

Figure 4: Water absorption test

2.2.3 COMPRESSIVE PROPERTIES TEST

The compression test is simply the opposite of the tension test with respect to the direction of loading. In some materials such as brittle and fibrous ones, the tensile strength is considerably different from compressive strength. Therefore, it is necessary to test them under tension and compression separately. Compression tests results in mechanical properties that include the compressive yield strength, compressive ultimate strength, and compressive modulus of elasticity in compression, % reduction in length etc.

All the compression tests of casted hybrid composites are conducted on 100 kN servo hydraulic UTM machine. Specimen configuration is shown in figure 5. All tests are conducted aspect ratio of 2.0. All tests are conducted under displacement mode of control. The displacement rate is 1mm/min and all tests conducted at room temperature.

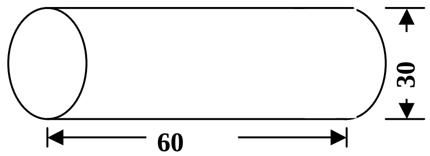

Figure 5: Specimen geometry for compression test according to ISO-1708, 1960.

3. Results and discussion

3.1 WATER ABSORPTION TEST

The effect of water absorption is important in case the material that has been developed when used for applications comes in contact of water. The effects were observed after 24 hrs and results are given in tables 1.

Table 1: Water absorption of coconut particle reinforced composite

S. No.	Coconut particle (20 wt %)	Coconut particle (25 wt %)	Coconut particle (30 wt %)	Coconut particle (35 wt %)
1	0.431%	0.483%	0.512%	0.518%
2	0.432%	0.482%	0.513%	0.520%
3	0.430%	0.481%	0.511%	0.516%
Mean	0.431%	0.483%	0.513%	0.517%

The water absorption capacity was found to be maximum for 35 wt % of coconut shell particle and rate of increase of water absorption was decreased near to 35 wt% reinforcement. This would be the effect of filling the voids by the amount of water near about 0.515%. Coconut particles would be showing more affinity towards itself. Space would be limited it will not be increasing. This is also the maximum size of voids that are possible to be produced. This may be come into picture after evaluating density as well as morphology analysis. Reinforcing up-to 30%wt is appropriate in view of water absorption. It would be the effect of very little space for water absorption among particles as shown in figure 6.

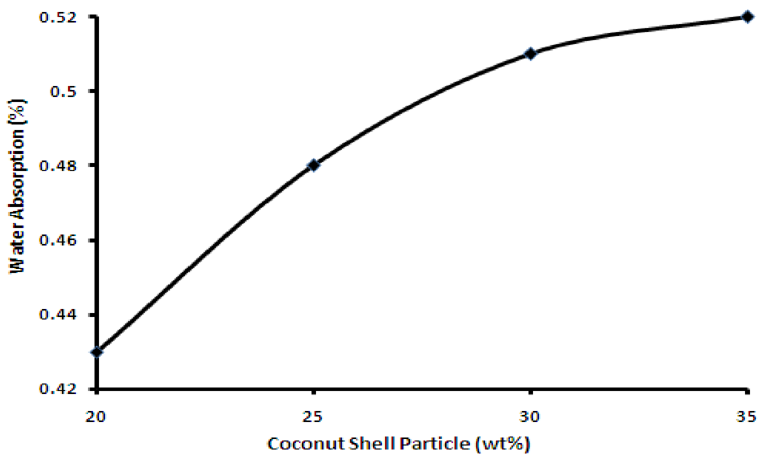

Figure 6: Water absorption of coconut particle reinforced composite

3.2 COMPRESSIVE PROPERTIES

Compressive strength is also a very important mechanical property required for bearing compressive load. Compressive properties are given in table 2. Composite with 30%wt of coconut shell particle shows very good ultimate strength and good modulus of elasticity in compressive zone in comparison to other wt% reinforcement of particles as shown in figure 7.

Table 2: Compressive strength of coconut particle reinforced composite.

Compressive Properties	Coconut particle (20 wt %)	Coconut particle (25 wt %)	Coconut particle (30 wt %)	Coconut particle (35 wt %)
Ultimate strength (MPa)	59.333	61.330	88.000	60.666
Modulus of elasticity (MPa)	582.490	620.490	698.630	552.490
% reduction	4.407	4.377	3.955	4.075

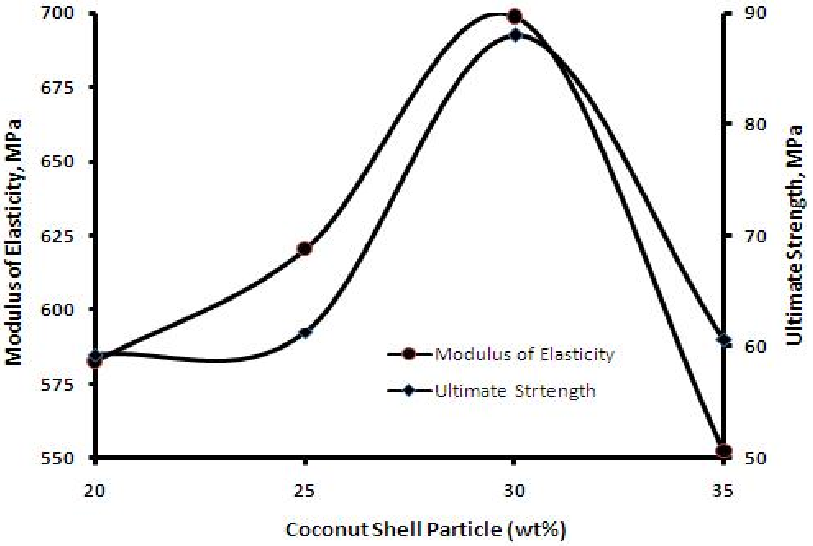

Figure 7: Ultimate strength and Modulus of elasticity variation with wt% of shell particle in compression

From stress strain diagram shown by figure 8 of coconut shell particle composite it is very clear that 30 wt% of particle is showing very good compressive strength in comparison to others. Linear behavior is also available for this combination of reinforcement. Compressive strength for 30%wt shell particle is maximum then reduces for 35%wt particle. Stress strain behaviour showed that 30 wt% reinforcement of particle gave good compressive strength. Compressive stress strain diagram was almost linear upto 1 strain rate. 30 wt % samples showed remarkable difference in stress strain diagram. All samples failed at 1mm/min strain rate. Compressive strength of 30%wt reinforcement was very close to compressive strength of Epoxy.

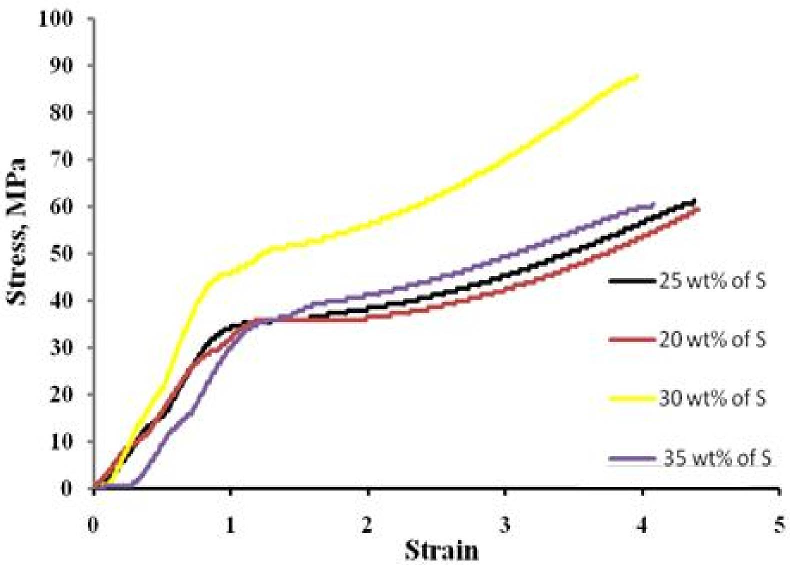

Figure 8: Stress-strain curve for shell particle composite only in compression.

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4. Conclusions

The water absorption capacity was found to be maximum for 30 wt % of coconut shell particle. Maximum compressive strength investigated was 88.0 MPa. Optimum combination is 30%wt reinforcement of coconut particle of 200-800 μm in view of water absorption and compressive strength. Size of voids are remain to be constant even after increase in reinforcement wt%. But it would be valid for a limited in increase in reinforcement. It is suitable for compressive application requirements and some time it is better option in view of other properties.

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