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Physical and Mechanical Properties of Coconut Shell Particle Reinforced-Epoxy Composite

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Abstract

The natural fibre reinforced composites are being developed to save environment. Objective of investigation was to evaluate the physical property-density and mechanical property-tensile 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 panels were made by casting method in open mould in very easy way. Experimental results showed that density, ultimate strength, modulus of elasticity and % elongation decreases with wt% of shell particle with in this range wt% 20-35 of reinforcement. Tensile strength of 25 MPa and modulus of elasticity of 654 MPa were retained even after of 35% reinforcement. Properties were comparable for application only with compromising slightly with matrix property.

Keywords **:** Weight percentage-wt%, shell-S, particle, matrix, reinforcement, density, tensile 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 fibre/particle provides 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 with out 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. *Bhaskar J & V K Singh* investigated the compressive properties of coconut powder composites **[6]**.

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 automatiove industry owing to its *hard-wearing quality and high hardness* (not fradile like glass fiber), good acoustic resistance, moth-proof, not toxic, resistant to microbial and fungi degradation, and not easily combustible.

Composite of high strength coconut filler can be used in broad range of applications as, building materials, marine cordage, fishnets, furniture, and other household appliances. The objective of this paper is to investigate the density and tensile properties of epoxy composite based coconut shell filler particles.

1.1. Particulate composite

As the name itself indicates, the reinforcement is of particle nature (platelets are also included in this class). It may be spherical, cubic, tetragonal, a platelet, or of other regular or irregular shape, but it is approximately equiaxed. 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, 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.

2. Materials and methods

2.1. 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. A approximate value of coconut shell density is 1.60 g/cm^3.

Figure 1: coconut shell

Figure 2: coconut shell particle

2.2. Epoxy Resin

Epoxy resin (ER) 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.

Brush Bond make epoxy resin SY-12(319) is a liquid solvent free epoxy resin. It has versatile applications in technical and industrial applications. Curing takes place at room temperature and atmospheric pressure after addition of hardener. Fully cured mixture has excellent mechanical, thermal properties and atmospheric attack. The castings have good ageing characteristics.

2.3. 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. (2002) [7].

2.4. Fabrication Methodology

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., 2002 [7]. 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 No 3 for specimen preparation for tensile, compression, wear and impact testing. Flat plates as required for tensile test. Tensile test specimens were prepared on milling machine as per ISO 527-2(1996).

Figure 3: Mould for plate casting

2.4. Density Calculation

Specimens of size 10x10x15 mm^3 were taken from casted panel. Weights of these samples were measured from weighing machine.

Density=mass/volume of sample

2.5 Tensile test

Tensile tests are used to determine the modulus of elasticity, elastic limit, elongation, proportional limit, and reduction in area, tensile strength, yield point, yield strength and other tensile properties. In the present investigation all the tensile tests are conducted as per ISO test procedure. The tests are conducted on 100 kN servo hydraulic UTM machine under different strain rates under displacement mode of control.

The different displacement rates are taken as 0.01 mm/min, 0.1 mm/min, 1mm/min 10mm/min and 100mm/min. All tests are conducted at room temperature. The results in form of stress-strain diagrams are presented in next chapter.

3. Results and discussion

3.1 *Appearance*

Appearance of coconut particle reinforced composite for various wt % are found to be opaque and dark brown in color. Coconut particle can be seen in cross sectional view as well as in transverse view.

3.2. *Density*

Density is one of the most important mechanical properties of the particle board material. The density of coconut shell particle reinforced composite for various wt % of particle are presented in Table No.1 and figure No.4.

From table No.1 and & figure No.4 it is observed that density decreases w.r.t. wt% of shell particle. But there is remarkable decrease of 0.14 g/cm^3 in density when wt% of shell particle changes from 28% to 35%. Here it is possible to comment that density decreases with increase of wt% of particle. The decrease in density can be related to the fact that the coconut particles are light in weight but occupy substantial amount of space. Particles are not closely bonded to each other due to open mould casting method.

Table 1: Density of coconut shell particle reinforced composite

S. No.	Coconut particle (20 wt %) (gm/cm^3)	Coconut particle (25 wt %) (gm/cm^3)	Coconut particle (30 wt %) (gm/cm^3)	Coconut particle (35 wt %) (gm/cm^3)
1	1.293	1.287	1.285	1.170
2	1.287	1.283	1.280	1.171
3	1.285	1.278	1.277	1.173
Mean	1.288	1.283	1.280	1.171

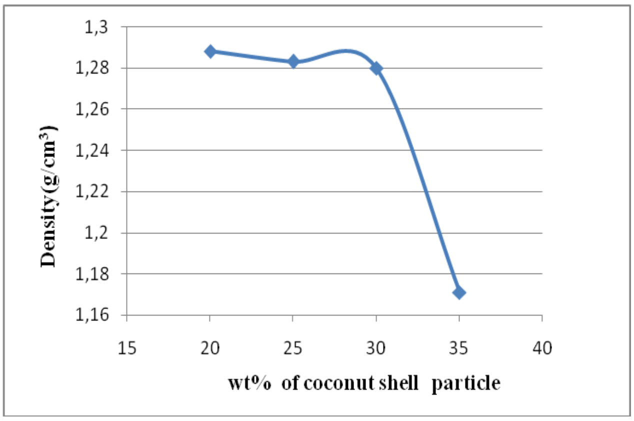

Figure 4: Density variation with reinforcement wt% of coconut shell particle

In the present investigation density of Coconut particle filled composite are found be 1.288 gm/cm³ for 20wt %, 1.283 gm/cm³ for 25wt%, 1.280 gm/cm³, for 30wt% and 1.171 gm/cm³ for 35wt%.

3.3. *Tensile properties*

The mechanical properties of the coconut particle filled epoxy resin composite materials were determined by universal testing machine at 0.1mm/min strain rate under displacement control mode.

Table 2: Tensile Properties of coconut shell particle reinforced composite

S.No.	20 wt% Shell powder reinforcement	25 wt% Shell powder reinforcement	30 wt% Shell powder reinforcement	35 wt%Shell powder reinforcement
Ultimate strength (MPa)	30.60	29.40	28.80	25.20
Modulus of elasticity (MPa)	856.00	756.00	684.00	654.00
% elongation	25.44	25.436	25.06	21.00

Tensile property of 43 MPa and modulus of elasticity 8000 MPa of cured matrix was supplied by material supplier. From table No. 2 it is clear that ultimate strength is maximum (28 MPa) for 20%wt of coconut shell particle. It reduces with the increase of wt% of shell particle. From literature it has been noticed that tensile properties increases with increase of particle size upto 0.250 mm size for 40%wt reinforcement [12 &13]. "*Saupan*" investigated that tensile properties (27-35 MPa) increases for coconut shell particle (50-200 µm) reinforced into epoxy upto 0-15wt% and decrease beyond 15 wt%.

The reinforcement in this investigation is more than "*Supan's* [12&13] investigations. Same fashion of decrement in the tensile properties was also observed. Tensile strength of 25 MPa was retained even after 35%wt reinforcement of shell particle. But it was quite appreciable when compared with tensile strength (24.8-19.8 MPa) and modulus of elasticity (633-318 MPa) respectively) of coir reinforced (5-15 wt%) polyster composite.

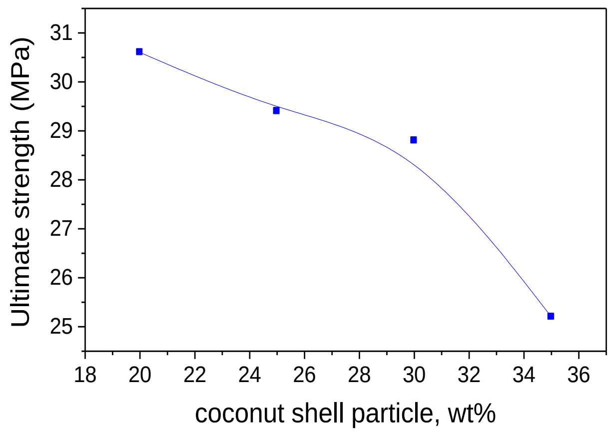

Figure 5 (a): Variation of ultimate strength with %wt of coconut shell particle

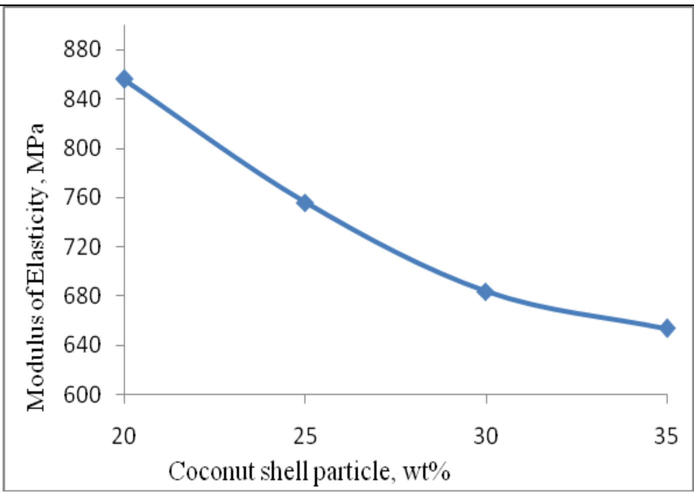

Figure 5 (b): Variation of modulus of elasticity with %wt of coconut shell particle

Modulus of elasticity also decreases with the increase of particle wt% reinforcement. In same fashion, change in modulus of elasticity % elongation was also decreasing with wt% of particle. Variation in ultimate strength, modulus of elasticity and % elongation was also observed from figure No. 5 (a, b & c).

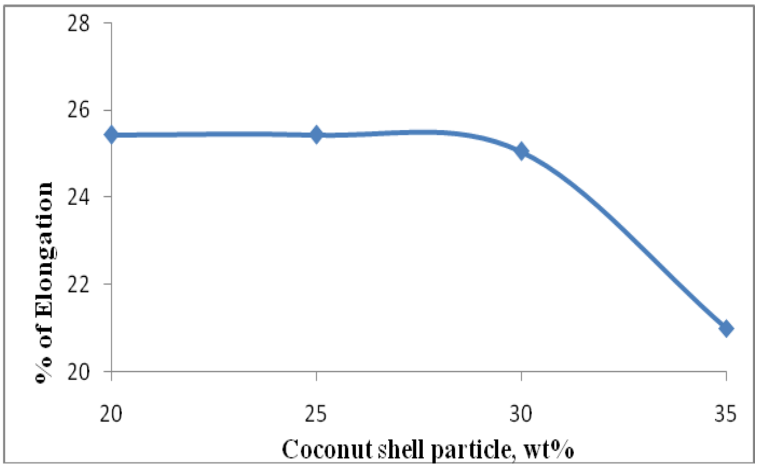

Figure 5 (c): Variation of % elongation with %wt of coconut shell particle

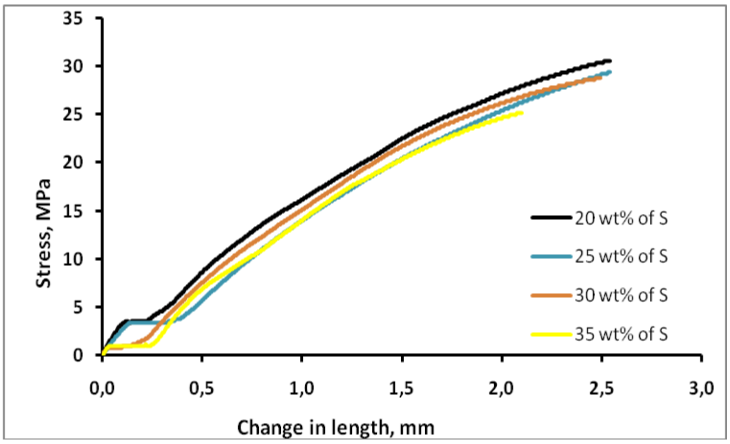

Figure 5 (d): Stress-Strain diagram for %wt of coconut shell particles.

It can be said that decreased tensile properties resulted from poor adhesion between the filler and thermoplastic since no coupling or dispersing agents were used. From figure No 5(d) stress-strain diagram for

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number of various particle wt% composite, it is observed that samples of wt% between 20% to 35% shows almost similar nature. But stress is maximum for 20%wt particle.

Stress-strain behavior of all four varieties of samples was observed linear at early stage of tensile test in figure No. 5(d). In rest portion of stress-strain diagram, all samples showed similar nature. Only wt% of 35 samples failed very first among four types of samples. This is also indication of poor adhesion of particles or direct contact of filler particles.

4. Conclusions

The Mechanical properties-tensile strength and modulus of elasticity was closely related to physical property-density. Decreasing value of density would be because of poor adhesion, direct contact of shell particles and void formation. This decrease of density resulted into decrease of tensile properties. Increase of wt% of reinforcement requires pressurized fabrication technique or addition of any adhesion increasing additive. Increase of proportion of particle size less than 200µm would be helpful to increase density as well as tensile properties.

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References

1. Michael P. Wolcott Karl England. *33rd International Particleboard / Composite Material Symposium,(1999) pp103-111*
2. Luo S. and Netravali A.N. *Ploymer composites, 20 (1999) 367-378.*
3. E.M Ahmed, B Sahari and P Pederson, *Proceeding of World Engineering Congress 1999, Mechanical and Manufacturing Engineering, Kuala Lumpur, 19-22 July,1999, pp. 537-543.*
4. Fuad M Y A, Rahmad S and Azlan M R N. *Proceeding of the Fourth International Conference on Advances in Materials and Processing Technologies, Kuala Lumpur, 24-28 August, 1998, pp. 268-275.*
5. Schneider J P and Karmaker A C, *J. Mater. Sci.*, 15 (1996) 201
6. Jitendra Bhaskar and V K Singh. *J. Mater. Environ. Sci.*, 4(1) (2013) 113-118.
7. Singh V. K., College of Technology Pantnagar. (2002)
8. Sapuan S.M., Harimi, Maleque M A. *Arab. J. Sci. Engin.*, 28 (2003) 171-181.
9. Devi K.A.; Nair C.P.R and Ninan K.N. *J. Polym. Polym. Comp*., 11 (2003) 551-558
10. Jitendra Bhaskar, Shamsul Haq, Yadaw S.B., *J. Thermoplastic Composite Mater.* SAGE (JTC), 25 (2012) 391-401.
11. Bhaskar J., Haq S., A K Pandey and N Srivastava. *J. Mater. Environ. Sci.* 3 (2012) 605-612
12. Sapuan S.M., Harimi M. and Maleque M. A., *Journal of Tropical Agriculture,* 43 (2005) 63.
13. Sapuan S.M., Zan M.N.M., Zainudin E.S. and Arora Prithvi Raj, *Arab. J. Sci. Engin.,* 28 (2003) 171.
14. Singh V. K. and Gope P.C., *Journal of Solid Mechanics,* 1 (2009) 233-244.