Experimental Investigation on Mechanical Performance of Coconut Shell Powder Reinforced Hybrid Polymer Composite

Shashikant Kushnoore, R B V Murali, P Naveen, P Ravi teja, K Guru Venkata Sai Krishna

Abstract: Reinforced Coconut shell powder homogeneous Epoxy composites are prepared by simple motorized stirring and pouring into ASTM standard mould respectively. Experimentations on mechanical characteristics of coconut shell powder reinforced homogeneous epoxy composites and its application in the current manufacturing industries are discussed. A systematic study has been carried out on effect of interactive influences with various material parameters on mechanical properties. A tests are conducted on a universal tensile and impact testing machine with different weight percentages (wt. %) such as 20, 30, 40 and 50 of reinforcement in the epoxy matrix. The sample with 40 and 50 wt. % of coconut shell powder reinforced composites shows the lower properties due to increase of reinforcement in composite have important effect on the tensile module, flexural strength and strength of the impact.

***Index Terms*: Coconut shell powder, Particulate epoxy composite, Mechanical Behaviour.**

I. INTRODUCTION

The advancements in current manufacturing industries have made a scope for production of new variety of materials. Composites with enhanced properties over the individual materials can be obtained by mixing two or more chemically distinct materials [1]. These composites could be natural or synthetic and were flexible in nature For multifunctional applications due to their important characteristics such as high module, bending rigidity, chemical resistance and specific strength [2-3].J.Olumuyiwa Agunsoye et al. [4].The mechanical properties of polyethylene matrix with coconut shell particles of 5 percent-25 percent volume fraction were prepared and investigated.They found that composite hardness increases with increased coconut shell content,although composite tensile strength, elasticity module, impact energy and modulus, impact energy and ductility decreases with increase in the particle content. Aradhyula thirumala vasu et al. [5] The composite was prepared using high density polyethylene as matrix and coconut shell powder (CSP) as reinforcement.The maximum tensile strength is obtained for the composite with a CSP volume fraction of up to 30 %. Composites with 40 percent CSP and above volume fraction also show lower strength.. Vignesh. K et al. [6] prepared the coconut shell powder (CSP) and coir fibre reinforced polyester resin composites and carried out an investigation on wear performance. The have found that increase of load in the CSP and coir fibre containing polymer matrix composites increases the coefficient of friction. It is also observed that increase in the applied load the wear rate increases and decreases with the addition of CSP and coir fibre. P. B Madakson et al. [7] The microscopic and spectroscopic characteristics of coconut shell ash were studied.They observed that ash has nearly the same chemical phases and other functional reinforcement groups, such as rice husk ash, fly ash, bagasse ash, which were specifically used for the application of automotive metal matrix components. Alok Singh et al. [8]

They reported an empirical approach for characterization and micro-scale manufacturing of three-dimensional novel coconut shell powder (CSP) reinforced polymer matrix composite (Epoxy-resin).They reported that the potential of 20% to 30% novel coconut shell powder reinforced composite as an alternative material for aircraft, motor car, spacecraft, ships and automotive interiors.. Z. H. Tengku Faisal et al. [9] Studied coconut shell (CS) mechanical properties, thermal properties and morphology as reinforcement of low-density polyethylene (LDPE) composites with acetic acid (acetylation) surface treated CS.They found that the elongation at break, tensile strength and Young's LDPE / CS composite module improved by acetylation treatment due to its nucleation.

S. M. Sapuan et al. [10] prepared the composites with three different filler contents such as 5%, 10%, and 15% of coconut shell filler particles and carried out the tensile and flexural tests. It was found that with increase in reinforcement material the tensile and flexural properties were improved, but increase of reinforcement material decrease the bonding between the reinforcement and matrix. Alok Singh et al. [11] developed a polymer matrix composite using different particle size and reinforcing in different volume of coconut shell powder (CSP). At 30 % of CSP filled shows maximum flexural and tensile strength while; with 40% CSP filled the flexural and tensile strength were minimum for the composite prepared. J. Bhaskar et al. [12] Manufactured coconut particles reinforced composites by reinforcing wt shell particles by wt.% of Percentage of 20, 25, 30 and 35 in epoxy matrix. They found that increase of wt. % of particle increases the water absorption but up to 30 wt. % of particle compressive properties increases as Compared to the actual

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compressive strength of composite, the percentage of particl e compressive properties increases. Manjunatha Chary G H and K Sabeel Ahmed [13] have evaluated mechanical properties like tensile, impact, flexural and hardness by filler volume fraction and particle size of coconut shell particles reinforced epoxy resin. The investigation showed that increase in the filler volume and filler particle size the tensile, flexural and impact properties decreases. B. Venkatesh [14] the composite was developed using epoxy resin as matrix an d coconut shell powder as reinforcement. The improved pro perties of tensile and hardness were found for 30 percent of coconut shell powder reinforcement. Tanya Buddi et al. [15] Prepare the composite by mixing Nano SiO2 with varying w eight percent and 5 wt. Percentage of wood powder in high density polyethylene by compression moulding process.It wa s revealed that the maximum tensile strength and flexural st rength was obtained at 5 wt.% Nano SiO2 percentage and m aximum impact strength at 3 wt. % of Nano SiO_2. Kammuluri Baburaja et al. [16] have successfully fabricated the aluminium with Bamboo leaf ash using Stir casting. They concluded that the 30 gm BLA has more yield strength and ultimate tensile strength compared to pure aluminium sample.

In this present study the coconut shell powder reinforced epoxy composites are prepared with coconut shell powder of less than 150 µm particulate size and varying wt. % such as 20,30,40and50. The specimens were prepared according to t he ASTM standards and the tensile, flexural and impact stre ngths were tested.

II Materials & Methods

Materials

The materials used to make composite are coconut shell pow der and epoxy. Coconut shell powder consists mainly of lign in and pentisans [5].Because of its high strength and modul us properties, coconut shell filler is a potential candidate for new composites. A shell density of coconut is approximately 1.60 g/cm3 [10]. The coconut shell powder is supplied from Ganesh suppliers Thannuku, West Godavari, A.P, India and its chemical composition is shown in Table A.1. The matrix epoxy (Lapox L-12) having medium viscosity and the hardener K-6 are supplied from Source and save ltd. Bangalore, India as shown in Table A.2. The reason for selecting epoxy as matrix because of good mechanical properties and excellent corrosive resistance.

Table A.1. Coconut Shell Powder Chemical Composition

Sl.No	Element	% of Composition
1	Lingin	29.4
2	Pentosans	27.7
3	Cellulose	26.6
4	Moisture	8
5	Solvent extractives	4.2
6	Uronic anhydides	4.1

Table A.2.Details of Hardener & Resin Details

Constituent	Trade Name	Chemical Name	Density (kg/m^3)	supplier
Resin	Lapox L-12	Diglycidyl ether of bisphenol A (DGEBA)	1162	Source and save ltd. Banglore
Hardener	k-6	Tri ethylene tetra amine (TETA)	954	Source and save ltd. Banglore

A. Fabrication of Composite

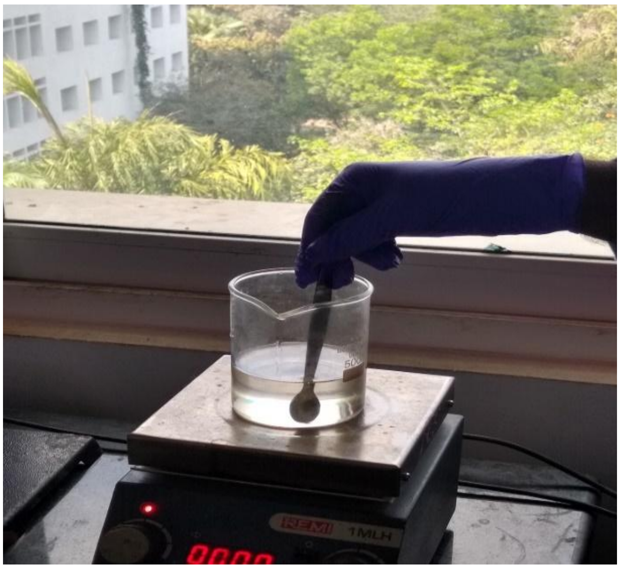
Table B.1 shows the different compositions of the composite s. In this method the coconut shell powder was properly mix ed with epoxy resin (Lapox L-12) in four different compositions with varying wt. % of 20, 30, 40 and 50 respectively. A wooden mould was prepared according to ASTM (American Society for Testing of Materials) standards with dimensions of 235*165*5 mm rectangular board (mould) as shown in Fig. B.1. The mould is wrapped with aluminium foil before pouring the composite in the mould so that there no chemical interaction with the wooden mould and the composite.

Table B.1. Composition of the composite

S.NO	Composite Designation	% of epoxy	% of coconut shell powder(CSP)
1	CSP 1	80	20
2	CSP 2	70	30
3	CSP 3	60	40
4	CSP 4	50	50

The uniformity of the coconut shell particles is obtained by sewing and the particle size is maintained in equal or below 150 microns. The calculated amounts of coconut shell powder and epoxy (Diglycidyl Ether of bisphenol A) by wt. % were taken. The weighed epoxy was taken in a glass beaker and then kept on mechanical stirring machine and it is heated up to 50 to 60 0C for some time to reduce the viscosity of the epoxy. After heating, the epoxy is mixed with coconut shell powder and stirred it continuously so that no bubbles are present in the mixture. Then, the beaker was kept in ultrasonic cleaner for 3-5 minutes to reduce the voids and cavitation's formed during the stirring process. The mixture was slowly poured in the centre of the mould, so that proper distribution of the mixture takes place throughout the mould and left for 20-24 hours to harden the composite as shown in Fig. B.2. The same method is applied for making remaining compositions. After the preparation of the composite cut it into proper shapes for testing as per the ASTM standard.

Fig. B.1. Wooden mould wrapped with aluminium foil



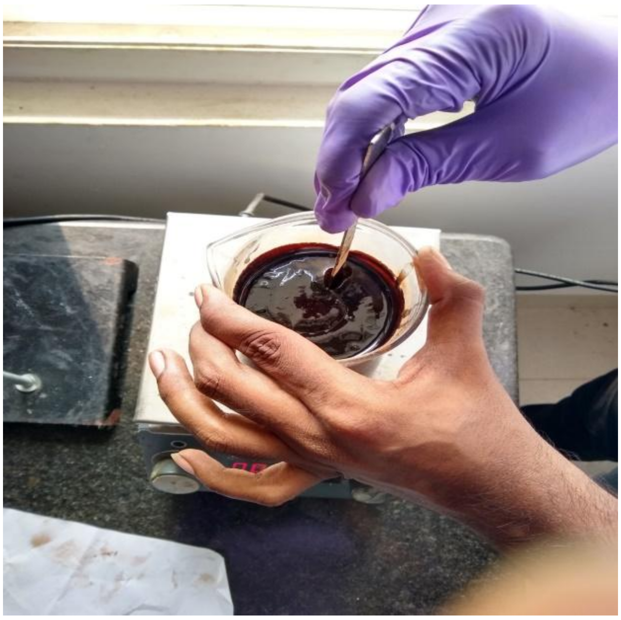


Fig. B.2. Preparation of composite

II. MECHANICAL PROPERTIES OF COMPOSITE

A. Tensile Strength

The tensile test was done on computerized universal testing machine having a 25 kN as maximum capacity of with a total frame height of 180 mm

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as shown in Fig. A.1. The standard used for testing was ASTM D-638 according to this standard 5 specimens were taken. Each specimen of dimensions 120*13*5 mm was mounted on machine so that one end was fixed and load was acted on the other end. At a certain loads the specimen will breaks, the load and elongation of specimens are shown digitally.

Fig. A.1. Tensile testing setup and test specimen

B. Flexural Test

The flexural test was conducted on automated universal testing machine by using 3 point bending method. The UTM have a maximum capacity of 25 KN, column clearance of 400mm, and total frame height of 1800 mm as shown in Fig. B.1. In 3 point bending, the loading is concentrated on center and according ASTM D790-91 the tests were performed. Initially the specimens were marked with the span length 'L' between center lines and between the support rollers. Place the specimens of dimensions 100*14*5 mm on the roller supports at center and fix the dial gauge at the load point at top centrally. Apply the load at the center of the span at rate of 1mm/min until the failure of specimen and results were obtained from the computer generated values.

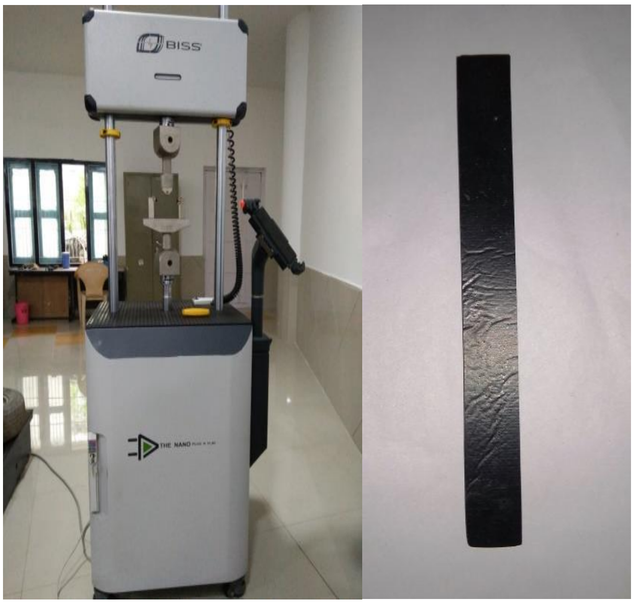

Fig. B.1.Universal testing machine and flexural test specimen

C. Impact Test

Izod impact testing machine was used for test having a maximum energy of 22 Joules and on scale one unit is equal to 0.20 joules. According to ASTM D-256 the specimens were tested. Tests were carried out on 5 specimens of dimensions 63.5*10*5 mm was fixed on a cantilever beam and the specimen wrecked by a blow delivered at a fixed distance from the edge of the clamp as shown in Fig. C.1. The energy required to break the specimen is indicated by a needle of the machine at the indicator.

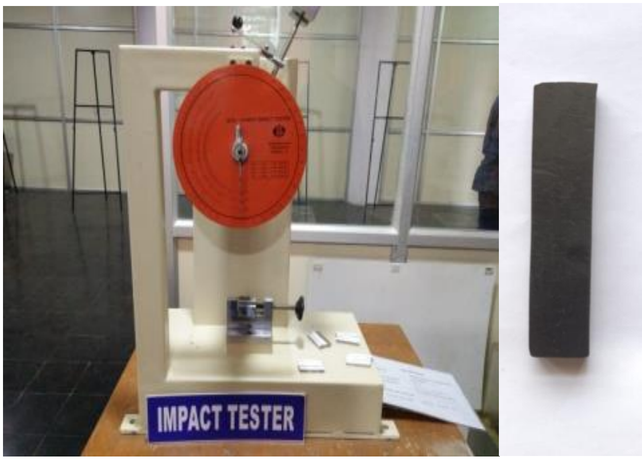

Fig. C.1. Impact test apparatus and test specimen

III. RESULTS AND DISCUSSION

The tests were conducted according to ASTM standards on different machines like Universal Testing Machine and Impact Tester. The results of 5 samples were taken and mean values of each combination as shown in Table A.

Table A. Maximum Tensile, Impact & Flexural Strength of Specimen

Name of the composite	Tensile Strength (MPa)	Flexural strength (MPa)	Impact strength (KJ/m)
CSP 1	19.937	97.37	62.52
CSP 2	23.762	105.919	63.11
CSP3	17.468	81.183	61.28
CSP4	13.818	46.52	58.40

Fig. A shows the variation in tensile strength with respect to composite grades. It has been observed that there is an incr ease in tensile strength up to the wt with the increase of rein forcement such as coconut shell powder in the epoxy matrix. Percentage of 30 and then decreases. The tensile strength decreases with increase of CSP in the epoxy matrix, it may be due to interfacial bounding imperfection [5, 15] Fig. B shows the flexural strength variation with respect to composite grades. It was observed that increase in flexural strength from 20% to 30% and again decreases from 30% to 50%. The variations in flexural strength with increased reinforcement CSP due to imperfect dispersion of coconut shell powder and also may due to imperfection in interfacial bounding [5]. It has been also observed that formation of weak spots with higher reinforced composites due to solution becomes the saturation state upon that CSP will not properly wet with epoxy.

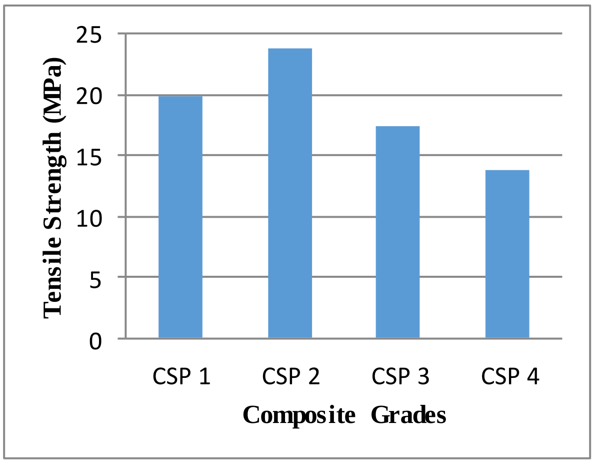

Fig. A. Tensile strength Vs variation in composite grades

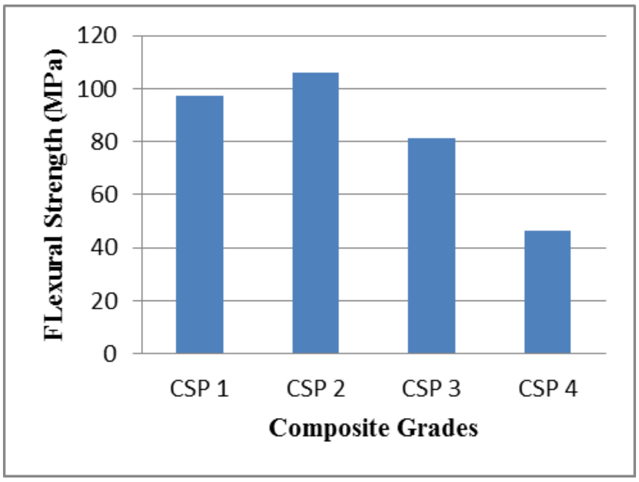

Fig. B. Flexural strength Vs variation in composite grades

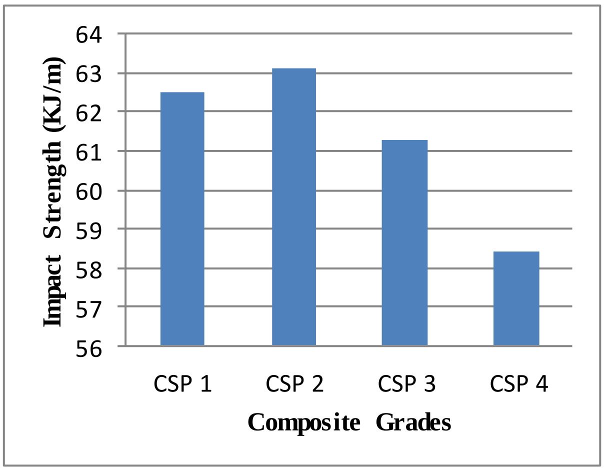

Fig. C. Impact strength Vs variation in composite grades

Fig. C shows that the distribution of coconut shell powder in each composite is uniform so there in no much variation in impact strength for each composite sample. It has been observed that the impact strength increases from 20% to 30% and then decreasing from 30% to 50%. This is mainly due to the interface bonding is strong between the epoxy and coconut shell powder. But decrease in the impact bending strength due to higher reinforcement content as the required energy to initiate the crack decreases [15].

IV. CONCLUSION

The experimental study of coconut shell powder enhanced p olymer hybrid composite results in mechanical behavior vari ations as follows.

- The composite with a 30 % of volume fraction, shows the maximum tensile strength.
- The 30 % of volume fraction of coconut shell power reinforced composite shows higher flexural strength, while with 40 % and 50% of volume fraction of coconut shell power reinforced composite decrease in flexural strength was obtained.
- The impact strength was found to be decreasing gradually with the increase of reinforcement up to 50 % of volume

fraction and it is maximum at 30 % of volume fraction coconut shell power reinforcement.

- Composites with 20 to 30 percent volume fraction co conut shell power enhanced polymer composites ca n be used as an alternative material for aircraft, shi ps, motor vehicles and automobiles.

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