Nat. Volatiles & Essent. Oils, 2021; 8(5): 3458 - 3467

Performance Evolution of Walnut Shell Particle Filled Glass Fiber Reinforced Composite

[1]Prabhakaran S, [2]Afifah Zaynab M, [3]Chinnarasu K, [4]Keerthana J

[1]Department of Robotics and Automation Engineering

PSG College of Technology

Coimbatore, India

spk.rae@psgtech.ac.in
[2]Department of Production Engineering
PSG College of Technology
Coimbatore, India
afifahnaveed@gmail.com

[3]Deaprtment of Mechanical Engineering

United Institute of Technology
Coimbatore, India

chinnarasu132@gmail.com
[4]Department of Production Engineering
PSG College of Technology
Coimbatore, India
jayakumarkeerthana8@gmail.com

Abstract
The choice of using eco-friendly materials in modern industries are the need of an hour. Glass fiber reinforced composites are famous today because of excellent mechanical properties but their non-biodegradable nature restricts the usage in industries. Use of natural fiber in polymer composites are increasing day by day in most of the non-load bearing applications. The synthetic composites with natural fillers provides both structural performance and also reduce the impact on the environment. The comparative performance of the glass-epoxy mixture with and without the influence of walnut shell powder particles was experimentally investigated. The panels are made by compression molding technique. Therefore, in the present study, an attempt was made to prepare and study the mechanical properties of a glass fiber reinforced composite filled with walnut shell powder particles, with different concentrations of fillers.

Keywords—Composite, Wall nut shell powder, Tensile test, Hardness test

I. Introduction

Technology advancements are happening day by day which requires a new class of materials to satisfy the needs of the modern industries that cannot be satisfied by any of the conventional materials. It leads to the search of new materials by the material researchers [1-2]. Composite materials are new class of it combining two or more materials to get the specific and better properties. It has two phases i.e., reinforcement phase and matrix phase. Reinforcement provides the properties based on the requirement whereas matrix holds the reinforcement in proper position and to transfer the load to the reinforcement [3]. It has been seen that reinforcement in composite alone does not fulfill the required properties in the applications. Henceforth, a suitable filler is sometimes required to achieve the desired properties. Artificial and natural fillers are used with the polymeric matrix composites [4]. Environmental policies are more stringent nowadays makes to use natural filler instead of artificial filler. Artificial fillers are non-biodegradable in nature makes them to restrict in usage even though its satisfies the primary requirement. Hence, filler materials derived from nature is the need of the moment. The another important part is the possibility of including agro-waste (agricultural residues including stalks of most bagasse, cereal crops, tamarind powder, coconut fibers, wall nut shells, peanut shells, rice husks and other wastes) product and recycled plastics with the advantage of a positive eco-environmental impact. They are many researchers they have used natural fibers and natural fillers in their research. Natural filler has good wear resistance, sound absorption, thermal insulation and damping properties. Some of the researchers they have already worked on composites with natural fiber and natural filler [5-7].

Manickam et al. investigated the mechanical and wear properties of vinyl ester polymer composites and conclude that the properties are improving as the roselle fiber content increases in the composite [8]. Olufemi et al. investigated the hair fibers along with cement in compacted laterite soil and concluded that the compressive strength increases when there is an increase in fiber loading [9].

Wear is an critical issue in most of the applications. The development of polymer composites with natural fillers has received increasing attention for these purposes. The use of natural fillers in the matrix gives rise to a variety of combinations that increase load carrying capacity, reduce coefficient of friction, improve wear resistance and improve thermal properties. Fiberglass increases the strength and load bearing capacity of the composite. The accumulation of solid lubricants inclines to reduce the friction coefficient and thus to reduce losses due to wear. Many researchers have reported that the wear behavior of polymers is improved by incorporating solid lubricants [10-13]. Deng et al. investigated the self-lubricating ability of Al2O3/Tic/CaF2 ceramic composites in sliding wear tests and during machining and concluded that the self-lubricating film formed consistently on the wear surface and acts as a lubricating additive between sliding couple [14]. Cho et al studied the solid lubricants for the automotive brake pad in order to understand the tribological properties (Graphite, Sb_2S_3, MoS_2) Solid lubricants reduced the friction and increase the hardness of the material [15]. As for as natural filler material is concern, walnut shell is considered as agro-waste and biodegradable nature can be used with composites has generated wide interest in automotive and aerospace engineering fields. Hence in this research paper walnut shell particle filled glass fiber reinforced composite has been fabricated and tested for their mechanical properties with different proportion of filler material.

II. MATERIALS, MANUFCATURING AND TESTING METHOD

A. Materials

Filler material used in composite is wall nut shell particles. They are abrasive in nature and are widely used in polishing, cleaning, tumbling, filtration, cosmetics, as well as anti-slip and filler applications. The nut shell is crushed and shredded into a fine powder less than 0.1mm in size. The wall nut shell and powder are shown in Figure 1 is a natural, biodegradable material with excellent mechanical properties. They are agro waste, will helps the farmer’s economy indirectly. The granules and powder of crushed walnut shells are already used in decorative furniture, sound panels in theatres, partition wall in buildings, and flooring panels in badminton court.

Figure 1 Preparation of Walnut Shell Flour

Fiber reinforcement for making the composite was chosen as E-glass due to their satisfactory mechanical properties. The fiber was purchased from Ayiswarya Polymers, Coimbatore with a surface density of 280 GSM.

Table 1 **Different combination of composites**

Specimen No	E-glass Fiber (%)	Epoxy Resin (%)	Walnut Shell powder (%)
1.	60	40	-
2.	55	40	5
3.	50	40	10
4.	45	40	15
5.	40	40	20

Composites were fabricated using epoxy resin as the matrix (LY556). Epoxy resins are selected primarily for their excellent mechanical properties, excellent adhesion to most materials and high boundary shrinkage on curing. In addition to the epoxy resin, epoxy hardener was added to accelerate the curing process (HY951). Epoxy resin and epoxy hardener were purchased from Covai Seenu & Company, India. Five specimens were prepared under the composition of fiberglass, epoxy, walnut shell powder and hardener. The different combinations of composites are listed in Table 1.

Initially hand lay-up process was followed to prepare the specimen in the different combination. Hardener was mixed with epoxy as 1:10 ratio in order to accelerate the curing. Figure 2 shows the hand layup process for manufacturing composites.

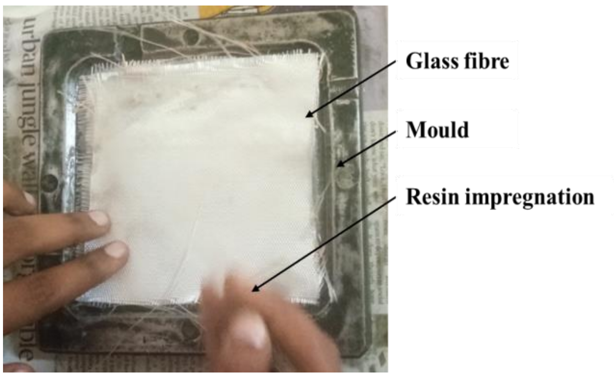

Figure 2 Hand layup process

Glass fibre are cut to the required dimensions and placed one by one. Filler material is mixed with epoxy as per the required proportions was spreads over the glass layer. This process will continue up to the desired thickness.

B. *Manufacturing*

The materials are prepared according to the proportion given in the Table1. Then each specimen is kept in compression molding machine at a pressure of 50 bar for 24 hours. Figure 4 shows the compression molding machine used for manufacturing composite plates.

Figure 4 Compression molding machine

The machine helps to remove the excess resin presents inside the laminates and provides higher volume fraction of fiber. The mechanical properties also improved because of higher amount of fiber presence and also less void content. The specimen manufactured from compression molding are shown in figure 5.

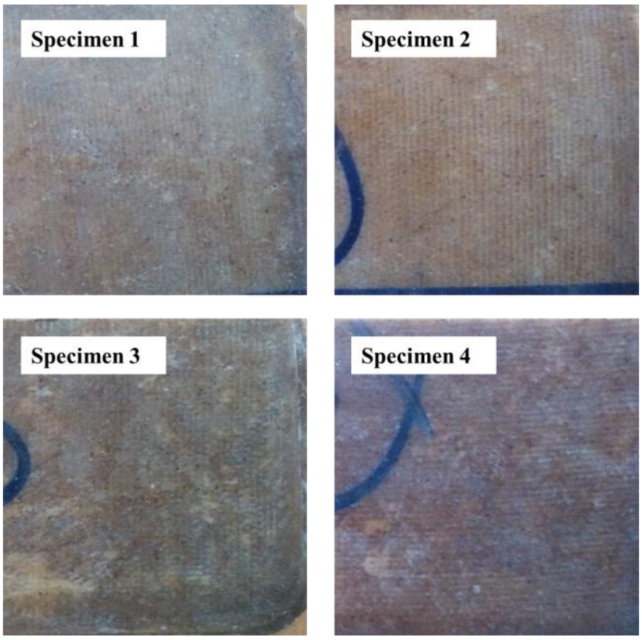

Figure 5 Different combination of composites

C. *Testing Method*

Tensile testing was performed using the Instron M8801 Universal Tester at a speed of 2 mm/min. The purpose of tensile testing is to determine the tensile strength and modulus of laminates. It is used to measure the force required to break a composite sample and the extent to which the sample is stretched. Tensile test specimens were tested according to ASTM D 3039. Figure 6 shows composite specimens during tensile testing.

Figure 6 Tensile Testing Machine

The dimensions of the test specimen is 250×25×2.5 mm as per the ASTM standard. Figure 7 shows the dimension of tensile test specimens. All the tests were performed in controlled environment i.e. 22 ± 2°C

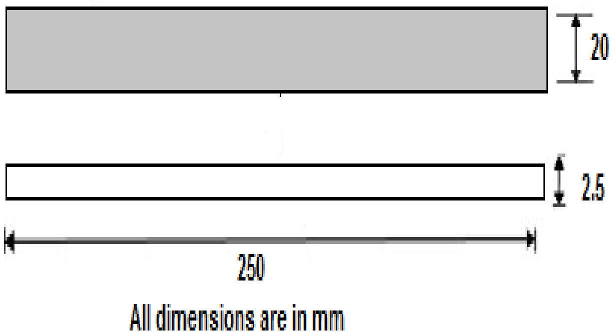

Figure 7 Dimensions of tensile test specimens

A compression test was performed upon the specimen to determine the ultimate compressive load. Figure 8 shows the compression testing machine. The specimen was placed between the two gripper. The crosshead is pushed together by a compression testing machine. A test specimen is contracted in the applied force direction. Compression test is essential for many applications where the compressive load is acting in the applications.

Figure 8 Compression Testing Machine

Hardness test is essential where the friction is come into picture. Higher hardness numbers imply harder materials; decreased numbers imply softer materials. Hardness can be described as a material's resistance to indentation. Durometer is one type of hardness tests, finds the intensity of an indentation. ASTM D2240 standard was used for measuring the hardness. If a timed hardness is desired, load is implemented for the specified time after which hardness value is read. The material undergoing the hardness test have to be at least 6.4 mm (0.25 inches) thick. Figure 9 indicates the hardness testing machine.

Figure 9 Hardness testing machine

III. RESULTS AND DISCUSSIONS

A. *Analysis of Tensile test*

The ultimate tensile load of glass-epoxy composites with walnut shell particulates as filler at varying proportions are listed in table 2.

Table 2 Tensile Test Results

Specimen No.	Ultimate Tensile strength (N/mm^2)	Ultimate Tensile Load (kN)
1	118.416	6.665
2	161.792	9.975
3	214.503	5.934
4	179.492	10.480
5	219.802	12.407

It is observed that the tensile load of the specimen under tensile test, increases as the filler content increases. The ultimate tensile load of 20% wall nut particles filled glass-epoxy composite (Specimen 5) is 86% greater than glass-epoxy composite without filler content (Specimen 1). The ultimate tensile load and strength increases due to the strengthening effect of the wall nut shell filler as filler provide rigidity and make the material stronger. Figure 10 shows the ultimate tensile load of composites with different filler proportions.

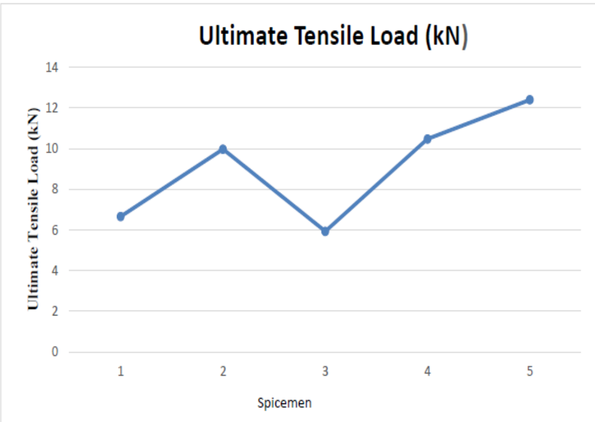

Figure 10 Ultimate Tensile Load

B. *Analysis of Compressive test*

The ultimate compressive load of glass-epoxy composites with walnut shell particulates as filler at varying proportions are listed in table 3.

Table 3 Compressive Test Results

Specimen No.	Ultimate Compressive Strength (N/mm^2)	Ultimate Compressive Load (kN)
1	9.398	0.260
2	8.435	0.520
3	8.883	0.500
4	9.934	0.580
5	12.755	0.720

From the compressive test, compressive load of the specimen under compression test, increases as the filler content increases. The ultimate compressive load of 20% wall nut particles filled glass-epoxy composite (Specimen 5) is 176% greater than glass-epoxy composite without filler content (Specimen 1). The ultimate compressive load and strength increases due to the strengthening effect of the wall nut shell filler as filler provide rigidity and make the material stronger. Figure 11 shows the ultimate compressive load of composites with different filler proportions.

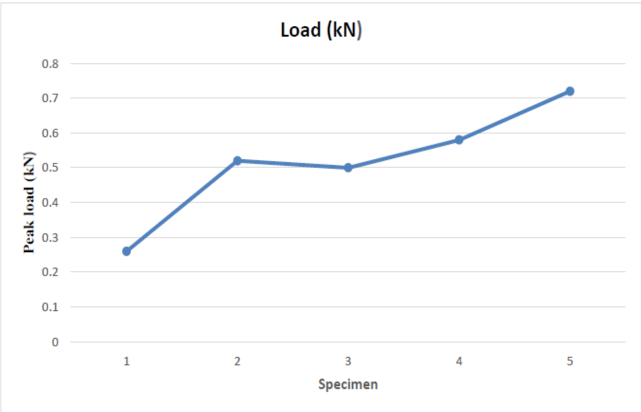

Figure 11 Ultimate Compressive Load

C. Analysis of Hardness Test

The hardness test for different composites were performed and Shore-D hardness test results are listed in the table 4.

Table 4 Hardness Test Results

Specimen No.	Shore-D Hardness Test
1	87
2	80
3	85

4	84
5	85

Figure 12 shows the variation in the value of Shore D hardness for the different proportions of filler particles. It is observed from the graph that the addition of walnut shell filler increases the hardness number of the glass-epoxy composite.

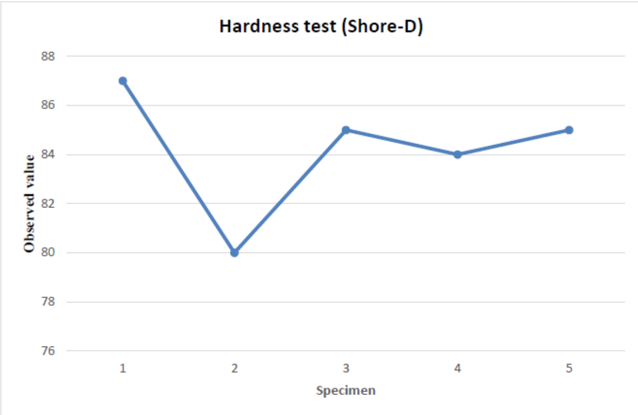

Figure 12 Hardness Test

IV. CONCLUSION

Glass epoxy composite materials can be effectively used in industry due to better mechanical properties such as good load carrying capacity and better surface properties. In this study, a tensile test, compression test and hardness test for epoxy glass composites with and without natural fillers were conducted. Tensile strength, compressive strength and stiffness number are increased as the nut shell filler increases. Noticeable changes in mechanical properties were observed due to the addition of walnut shell particles as filler in the epoxy glass mixture. The addition of walnut shell particles increases stiffness, which is an important property for particle boards with acceptable tensile and compressive properties.

REFERENCES

1. Mohanty AK, Misra M, Drzal LT, editors. Natural fibers, biopolymers, and biocomposites. CRC press; 2005 Apr 8.
2. Prabhakaran S, Kumar MS. Development of glass fiber reinforced polymer composite ceiling fan blade. 2012 July,2 (3), 59-64.
3. Hsissou R, Seghiri R, Benzekri Z, Hilali M, Rafik M, Elharfi A. Polymer composite materials: A comprehensive review. Composite Structures. 2021 Jan 26;262:113640.
4. Zaaba NF, Ismail H. A review on peanut shell powder reinforced polymer composites. Polymer-Plastics Technology and Materials. 2019 Mar 4;58(4):349-65.
5. Prabhakaran S, Krishnaraj V, Zitoune R. Sound and vibration damping properties of flax fiber reinforced composites. Procedia Engineering. 2014 Jan 1;97:573-81.
6. Alavez-Ramirez R, Chiñas-Castillo F, Morales-Dominguez VJ, Ortiz-Guzman M. Thermal conductivity of coconut fibre filled ferrocement sandwich panels. Construction and Building Materials. 2012 Dec 1;37:425-31.

7. Dhawan V, Singh S, Singh I. Effect of natural fillers on mechanical properties of GFRP composites. Journal of Composites. 2013 Jul 8;2013.
8. Manickam C, Kumar J, Athijayamani A, Diwahar N. Mechanical and wear behaviors of untreated and alkali treated roselle fiber-reinforced vinyl ester composite. Journal of Engineering Research. 2015 Sep;3(3):1-3.
9. Oluremi JR, Adedokun SI, Yohanna P, Fadiran DA, Azeez IO. Evaluation of compacted laterite soil admixed with cement and hair fibres as road construction material. Journal of Engineering Research. 2020 Mar 5;8(1).
10. Marhoon I. Effects of the addition of Pistachio shell particles on the properties of polyurethane matrix composite. International Journal for research in Applied Science & Engineering Technology. 2016;4:445-9.
11. Agunsoye JO, Isaac TS, Samuel SO. Study of mechanical behaviour of coconut shell reinforced polymer matrix composite. Journal of minerals and materials characterization and Engineering. 2012 Aug 1;11(8):774-9.
12. Kumar MA, Reddy GR, Reddy GH, Reddy KH, Reddy Y. Fabrication and performance of hybrid betel nut (Areca catechu), short fiber (Sansevieria cylindrica: Agavaceae) epoxy composites. Journal of Metallurgy and Materials Science. 2011;53(4):375-86.
13. Mohammed L, Ansari MN, Pua G, Jawaid M, Islam MS. A review on natural fiber reinforced polymer composite and its applications. International Journal of Polymer Science. 2015 Oct 1;2015.
14. Deng J, Liu L, Yang X, Liu J, Sun J, Zhao J. Self-lubrication of Al2O3/TiC/CaF2 ceramic composites in sliding wear tests and in machining processes. Materials & design. 2007 Jan 1;28(3):757-64.
15. Cho MH, Ju J, Kim SJ, Jang H. Tribological properties of solid lubricants (graphite, Sb2S3, MoS2) for automotive brake friction materials. Wear. 2006 Apr 7;260(7-8):855-60.