Study of Mechanical Properties of Coconut Shell Powder Reinforced Glass-Epoxy Composites

Vijaylaxmi[1], Ambadas Kadam[2], Babu Reddy[2], Sandeep Bansode[3]

[1]*Department of Machine Design student, Visvesvaraya Technological University Regional Centre Kalaburagi, Karnataka- 585106*

[2]*Department of Machine Design Assistant Professor Visvesvaraya Technological University Regional Centre Kalaburagi, Karnataka 585106*

[3]*Department of Mechanical Engineering Assistant Professor Guru Nanak Dev Engineering College, Bidar, Karnataka - 585403.*

Abstract - The purpose of project is to analyze mechanical behavior of coconut shell particles with E-glass fibers of different gsm and epoxy resin composite. In this work 300, 400 & 600gsm E-glass fiber composite panels were prepared with different volume fractions of coconut shell powder (5%, 10% & 15%) by using traditional hand layup method along with rule of mixture. Specimens were prepared and tested according to ASTM standard. The mechanical strengths such as tensile, flexural and impact are evaluated. From the result it is found that the tensile and impact strength decreases with the increase in volume fraction of coconut shell particles. But flexural strength increases with increase in volume fraction of coconut shell particles. The comparative study reveals that 400gsm E-glass fiber having 15% volume fraction of coconut shell powder exhibits maximum flexural strength.

Keywords: E-glass fiber of 300gsm, 400gsm, 600gsm, Epoxy, Hardener, Coconut shell powder, tensile; flexural; impact.

I. INTRODUCTION

Over the last 3 decades, composite materials, plastics and ceramics have been the dominant emerging engineering materials. The volume and number of applications of composite materials have grown steadily, penetrating and conquering new markets relentlessly [1].

The improvement of the mechanical properties of natural fiber reinforced materials. The mechanical strength of the natural fiber reinforced polymer composites (NFRPCs) has been compared with that of glass fiber reinforced polymer composites and it is found that for achieving equivalent mechanical strength of the material, the volume fraction of the natural fiber should be much higher than that of the glass fiber. The eco-friendly nature (emission, economy of energy) of the production of components of NFRPCs has also been briefly discussed. It is concluded that NFRPCs have already been proven alternative to SFRPCs in many applications in automotive, transportation, construction and packaging industries [2].

The interest in natural fiber reinforced polymer composite materials is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable [3-6]. Plants such as flax, cotton, hemp, jute, sisal, pineapple, ramie, bamboo and banana have satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and man-made fibers used for the manufacturing of composites [7-12].

Coconut shells are available in abundance in tropical countries as a waste product after consumption of coconut water and meat. Such abundance can fulfill the demand of filler based composites while reducing waste. Procurement and processing of coconut shell powder is cost effective than other artificial fillers. Flexural and tensile properties of coconut shell reinforced polyester composite are studied by S.Husseinyah and M.Mustaph [13-18]. They prepared the composite by using coconut shell powder as filler (0, 15, 30, 45 and 60% by weight). Their result indicated better flexural and tensile strength of polyester composites compared to un-reinforced samples. The morphology and mechanical properties of coconut shell reinforced polyethylene composite have been evaluated to establish the possibility of using it as a new material for engineering applications. Coconut shell reinforced composites was prepared by compacting low density polyethylene matrix with 5% - 25% fractional volume of coconut shell particles and the effect of particles on the mechanical properties of the composite produced was investigated. The result shows that the hardness of the composites increases with increase in coconut shell content though the tensile strength, modulus of elasticity, impact energy and ductility of the composite decreases with increase in the particle content [19].

II. MATERIALS AND METHODS

Coconut shell powder

Coconut shell particles used as reinforcing material for investigation. Shell particles of size between 200-800µm are prepared in grinding machine. Coconut shell filler are potential candidate for the development of new composites because of their high strength and modulus properties. An approximate value of coconut shell density is 1.60g/cm³. Coconut shell powder has various uses. The shell particles are manufactured from the coconut shell which is obtained as byproduct from coconut oil industries and individual households. This powder has various uses as filler in synthetic resin glues, filler and extender in phenolic molding powders, mosquitoes repellent coils, mastic adhesives, resin coating, bituminous products etc. The coconut shell powder used for the study shown in Figure 1.

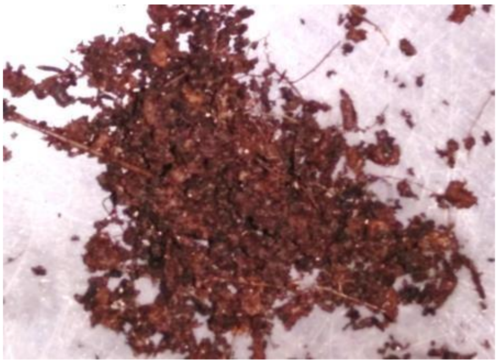

Figure 1: Coconut shell powder

Glass fiber

Glass fiber is most usually utilized strengthening materials as a part of polymer lattice composites. Glass strands are gathered in three groupings, E-glass, S-glass and C-glass. E-glass is electrically resistive glass made with alumina-calcium borosilicate. The polymer composites most normally utilized as a part of commercial enterprises. In the current study bi-directional E-glass fiber of 300, 400 and 600 GSM is chosen as fortifying material shown in Figure 2.

a) 300 gsm

b) 400 gsm

c) 400 gsm

Figure 2: E-glass fiber of 300, 400 & 600 gsm

Epoxy resin

Epoxy LY 556 resin was used. It is chemically belonging to the “epoxide”, family and it is used as the matrix material. Its common name is Bisphenol-A-Diglycidyl-Ether. Because of insulating property Epoxy is chosen. Epoxy used as glue, holding, development materials (deck, clearing and totals), composites, covers, coatings, trim and material wrapping up. In below figure 3 the appearance of epoxy resin is shown.

Figure 3: Epoxy Resin Araldite LY 556

Figure 4: Hardener HY951

Hardener

Hardener Araldite HY951 hardener was used as a binder during the fabrication. It has low viscosity, cure at room temperature, superior mechanical strength, and highquality resistance to atmospheric and chemical degradation. Below figure 4 shows the appearance of hardener.

Fabrication of Composites

There is a wide variety of fiber-reinforced plastic processes. The choice of process depends on many factors, such as type of reinforcement and matrix materials, size, shape, quantity and cost. There are many specialized processes available, but only the most commonly used commercial process, hand lay-up, has been used here in the preparation of the composites.

The glass epoxy laminates were prepared by keeping 65% volume fibers and 35% resin. The filler material with varying concentrations of coconut shell powder (5%, 10% and 15% volume) was added as shown in "Table 1". The volume fraction of fiber, epoxy and filler materials were determined by considering the density, specific gravity and mass.

Required number of Fibers of size 250mm X 250mm was marking and cut using cutter. Cut Fibers of size 250mm X 250mm and weigh the Fiber. Calculated amount of resin and hardener and coconut shell powder was weighed using a physical balance and poured into a container and the contents were mixed well.

Mylar sheet was put on the imaginative tile and wax was then joined on lamina. Sap hardener mix was joined with the Mylar sheet using a spreader and glass fiber utilizes was then put on the sheet. Proper mixing of Resin-hardener & coconut shell powder mixture was applied to the ply until the entire ply gets uniformly distribute of resin and hardener. The next ply was placed and the same procedure was repeated for all other plies. Another Mylar sheet was stacked on the highest utilizes and the example was moved utilizing a roller. Another ceramic tile was placed over this Mylar sheet and the specimen was allowed to cure at 50^0 C temperatures for 2 hours by keeping it in a digital oven or cure for 24hrs.

Sl. No.	Glass fiber content % (Mat- 300, 400 & 600 GSM)	Epoxy resin %	Coconut Shell Powder %
01	60	35	5
02	55	35	10
03	50	35	15

Table 1: Composition and Volume fraction of the coconut shell powder and Glass Epoxy composites

III. MATERIAL TESTING

Tensile Test

A tensile test, also known as a tension test, is probably the most fundamental type of mechanical test performed on any material. Tensile tests are simple, relatively inexpensive and fully standardized. As the material is being pulled, we can establish its strength together with how much it will elongate. The point of failure of the material is of significant interest and it is typically called its "Ultimate Tensile Strength" (UTS). The tensile curves of some materials do not have a very well defined linear region. In these cases, ASTM Standard D638 provides for alternative methods for determining the modulus of a material, in addition to the Young's modulus. Tensile testing is done in a tension configuration in which 10-ton capacity high precision UTM, supplied by Kalpak Instruments and Controls, Pune, INDIA. The rate of loading is maintained at 4mm/min. Distance between two supports are maintained at a distance of 80mm apart. The specimens tested for tensile strength as per ASTM-D638. Specimens of Length: 125 mm, Thickness: 2 mm and Width: 12.5 mm.

Flexural Test

Flexural strength, also known as the modulus of rupture, bend strength, or fracture strength, is a mechanical parameter for brittle materials, which is defined as the ability of the material to resist deformation under a load. The flexural strength represents the highest stress experienced within the material at its moment of rupture. It is measured in terms of stress. Flexural strength of the specimens determined for different percent of coconut shell particle and different GSM of fiber glass by the three-point bending test as per ASTM-E290. The specimens (96 X 12.5 X 2mm) tested with a spam length of 50 mm in air using an instrumented 10 ton capacity UTM. The flexural strengths were resolute via the formula,

$$FS = (3PL) / (8t^2) \qquad \text{Eq. 1}$$

Where P is peak load, L is length and t is thickness.

Impact Test

The impact test designed to give information on how a specimen of a known material will respond to a stress applied suddenly, e.g., shock. Impact strength of specimens determined by using Izod / Charpy Impact Tester by pendulum method. This method covers two test for Izod (horizontal impact on vertically clamped specimen) & Charpy (vertical impact on the horizontally placed specimen). In this experiment charpy set up is used, the specimens were tested as per ASTM-D256 the specimen has dimensions, Length: 63.5mm, Thickness: 3mm and Width: 12.7mm.

IV. RESULTS AND DISCUSSION

Tensile test results

The results obtained from the tension test for the different gsm glass fiber and different volume fraction of coconut shell powder is tabulated in Table 2. In addition, the tensile properties coconut shell powder reinforced glass-epoxy composites were measured and they are tabulated in Table 2. The tensile strength of these composites was compared using the line graph, as shown in Figure 5. It was found that as the percent of coconut shell powder increases the tensile strength goes on decreasing. Comparing the tensile strength of all varying percent of coconut shell powder and glass fibers 400gsm fiber glass composite gives the best result. The values of Young's modulus were also compared using the line graph shown in figure 6.

Sr. No.	E- Glass Fiber	% of Coconut Shell Particle	Peak Load (N)	Average Peak Load (N)	Ultimate Tensile Strength (MPa)	Average Tensile Strength (MPa)	Young's modulus (Mpa)	Average Young's Modulus (MPa)
1	300 GSM	5	5766	5695	230.66	227.85	E1-78.13	76.565
			5626		225.04		E2-75.00	
		10	5356	5352.5	214.6	214.25	E1- 53.24	49.61
			5349		213.9		E2- 45.98	
		15	3912	4246	156.5	169.85	E1- 39.54	40.15
			4580		183.2		E2- 40.77	
2	400 GSM	5	7158	7469	286.3	298.75	E1- 49.17	49.585
			7780		311.2		E2-50.00	
		10	6852	7055.5	274.1	282.2	E1- 50.78	52.14
			7259		290.3		E2- 53.50	
		15	5787	5795	231.5	231.8	E1- 57.42	57.80
			5803		232.1		E2- 58.18	
3	600 GSM	5	5032	5046.5	201.2	201.8	E1- 41.30	45.065
			5061		202.4		E2- 48.83	
		10	4310	4720	172.4	188.8	E1- 42.20	42.995
			5130		205.2		E2- 43.79	
		15	4935	4621.5	197	184.5	E1- 44.74	53.33
			4308		172		E2- 33.33	

Table 2: Tensile Strength and Young's modulus of specimens

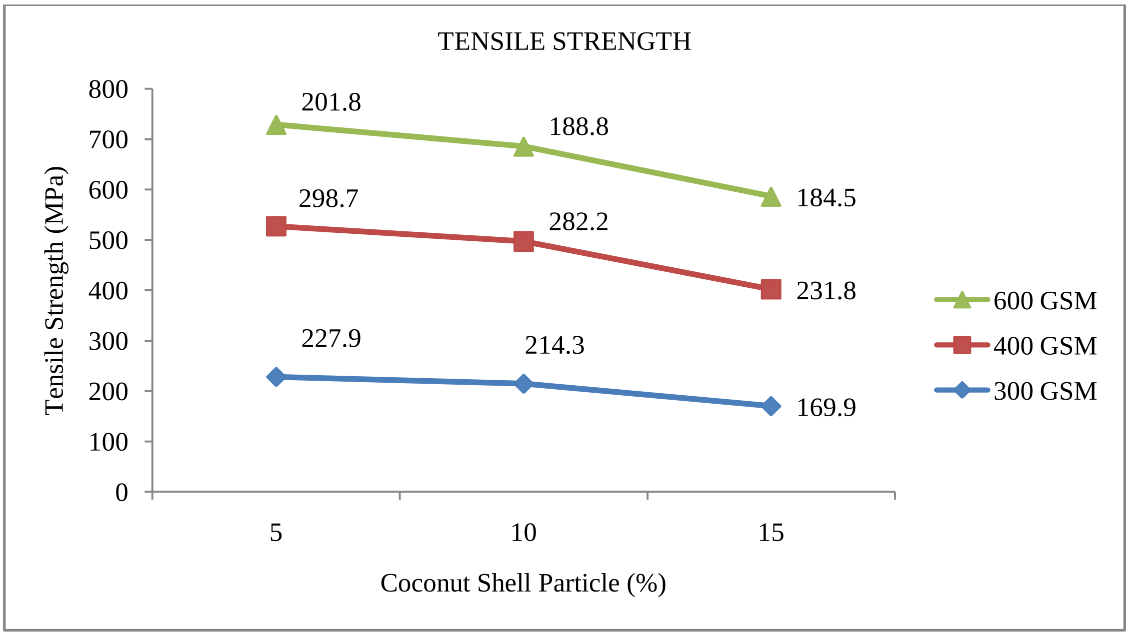

Figure 5: Comparison of tensile strength

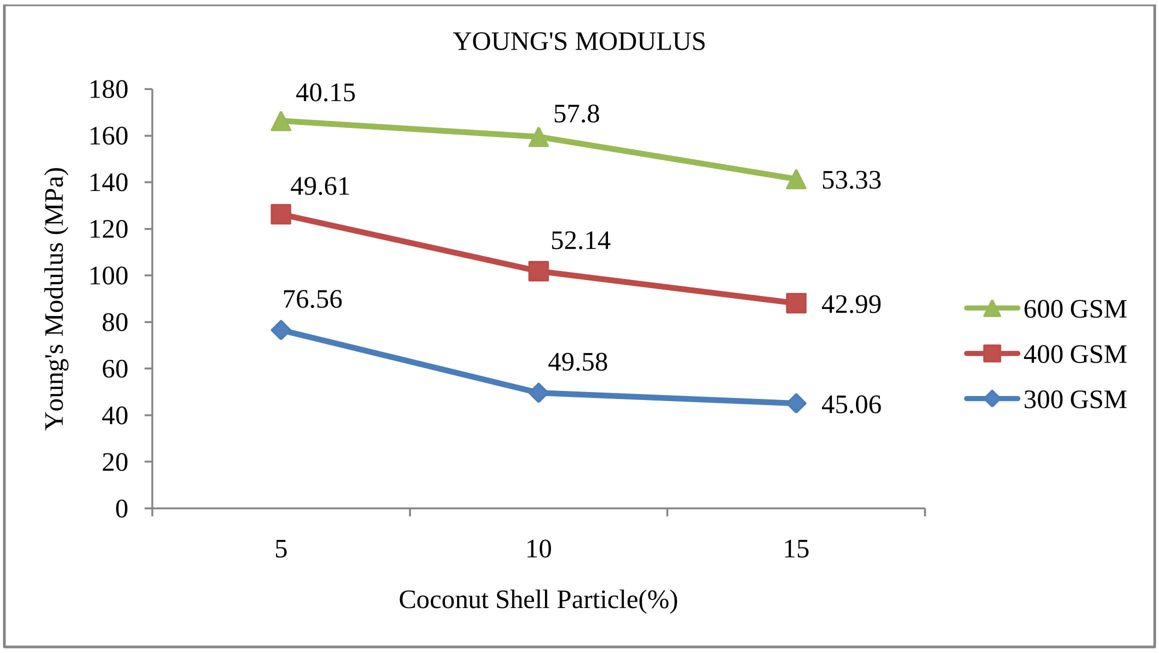

Figure 6: Comparison of Young's Modulus

Flexural test results

The results obtained from the flexural test for different gsm glass fiber and different volume fractions of coconut shell powder are tabulated in Table 3. In addition, the flexural properties coconut shell powder reinforced glass-epoxy composites were measured and they are tabulated in Table 3. The flexural strength of these composites was compared using the line graph, as shown in Figure 7. It was found that as the percent of coconut shell powder increases the flexural strength goes on increasing. Comparing the flexural strength of all varying percent of coconut shell powder and glass fibers 600gsm fiber glass composite gives the best result.

E-Glass Fiber	% of Coconut Shell Particle	Peak Load (N)	Average Peak Load (N)	Flexural Strength (MPa)	Average Flexural Strength (MPa)
300 GSM	5	73.10	76.16	657.9	685.15
		79.16		712.4	
	10	86.74	103.145	780.66	928.30
		119.55		1075.95	
	15	106.65	111.25	959.85	1001.25
		115.85		1042.65	
400 GSM	5	53.33	60.175	479.97	541.17
		67.02		603.18	
	10	106.04	92.89	954.36	836.01
		76.74		717.66	
	15	160.58	139.43	1445.22	1254.87
		118.28		1064.52	
600 GSM	5	759.825	759.825	84.425	84.425
		759.825		84.425	
	10	11.63	99.155	1004.67	905.895
		89.68		807.121	
	15	146.8	118.98	1321.2	1070.95
		91.16		820.395	

Table 3: Flexural strength of specimens

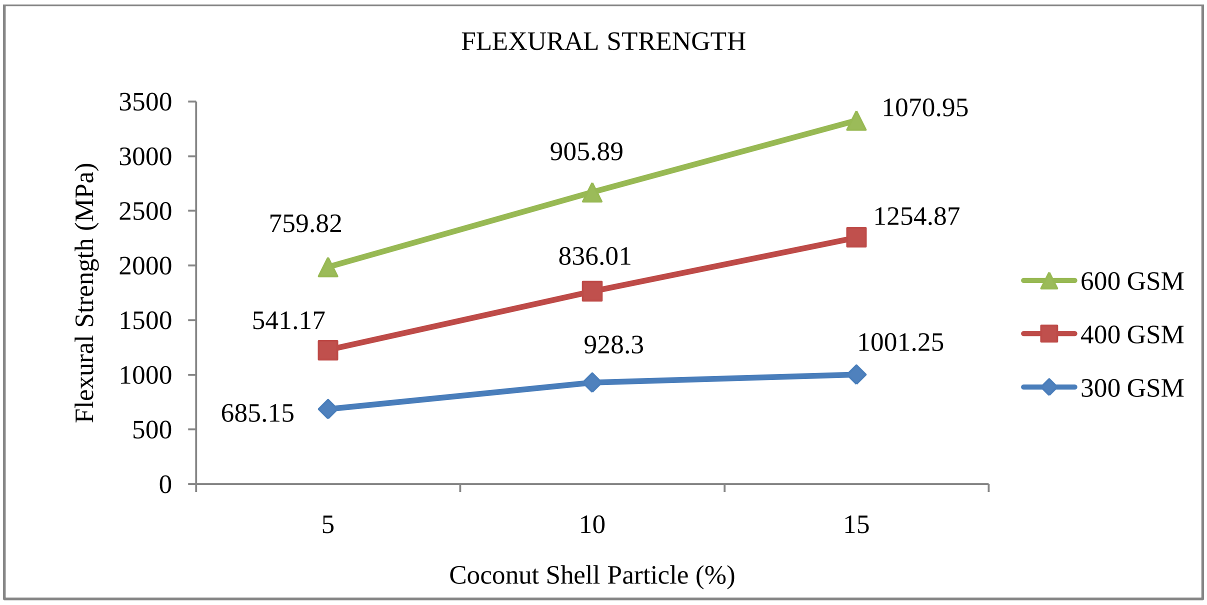

Figure 7: Comparison of Flexural strength

Impact test results

The results obtained from the impact tests for the different gsm glass fiber and different volume fraction of coconut shell powder are tabulated in Table 4. The impact strengths of these materials were compared using the line graph shown in Figure 8. It was found that as the percent of coconut shell powder increases the impact strength goes on decreasing. Comparing the tensile strength of all varying percent of coconut shell powder and glass fibers 400gsm fiber glass composite gives the best result.

Coconut Shell Particle (%)	Impact Strength (J/min) of 300 GSM Glass Fiber	Impact strength (J/min) of 400 GSM Glass Fiber	Impact Strength (J/min) of 600 GSM Glass Fiber
5	3.11	4.59	3.88
10	2.88	3.81	2.24
15	1.54	2.45	1.20

Table 4: Impact strength

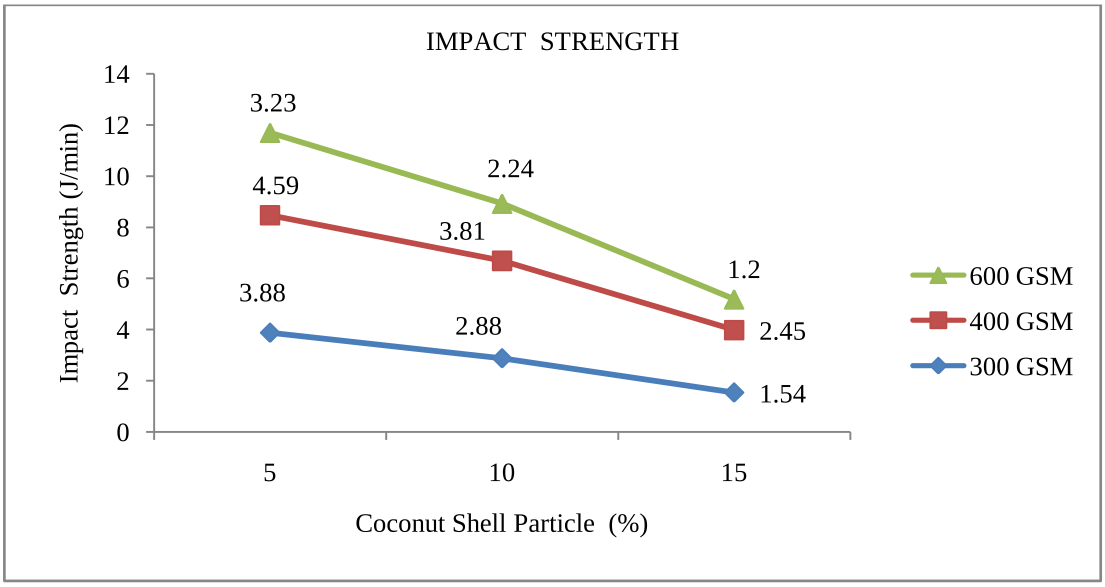

Figure 8: Comparison of Impact strength

V. CONCLUSION

The experimental investigation on mechanical behavior viz. Tensile strength, Flexural strength & Impact strength of Coconut shell epoxy composite. Material is greatly influenced by the Coconut Shell Powder filled volume fraction. The maximum tensile strength 298.75MPa is obtained for the composite prepared with 400gsm fiber glass with 5% coconut shell powder volume fraction. The minimum tensile strength 169.9 MPa is obtained for the composite prepared with 300gsm fiber glass with 15% coconut shell powder volume fraction. The tensile strength curve (see figure 5) shows an increase of filler volume the tensile strength goes on decreasing.

The maximum flexural strength 1254.87MPa is obtained for the composite prepared with 400gsm fiber glass with 15% coconut shell powder volume fraction. The minimum flexural strength 541.17MPa is obtained for the composite prepared with 400gsm filled with 5% volume fraction of coconut shell powder. The flexural strength curve (see figure 7) shows an increase of filler volume fraction the flexural strength goes on increasing.

The maximum impact strength 4.59 J/min is obtained for the composite prepared with 400gsm fiber glass with 5% coconut shell powder volume fraction. The minimum impact strength 1.20 J/min is obtained for the composite prepared with 600gsm fiber glass with 15% coconut shell powder volume fraction. The impact strength curve (see figure 8) shows an increase of filler volume the impact strength goes on decreasing.

VI. REFERENCES

[1] T. Prakash, Processing and Characterization of Natural Fiber Reinforced Polymer Composites, National Institute of Technology, Rourkela, 2009.

[2] Begum K and Islam M.A, Natural Fiber as a substitute to Synthetic Fiber in Polymer Composites: A Review, Research Journal of Engineering Sciences 2013; 2(3): 46-53.

[3] M.A.Gulbarga and S.B.Burli, Jute Fiber-PP Bio-Composite: State of art, Low Investment, In-House and Manual Preparation of Injection moldable Bio- Composite Granules, International Journal of Scientific Research publications 2013; 3(8): 2250-3153.

[4] J.Kasama and S.Nitinat, Effect of glass fiber hybridization on properties of sisal fiber–polypropylene composites, Elsevier 2009; 623-627.

[5] S.V.Joshi, L.T.Drzal, A.K.Mohanty and S.Arora, Are natural fiber composites environmentally superior to glass fiber reinforced composites. Elsevier 2004; 371–376.

[6] P.J.Roe and M.P.Ansell, Jute reinforced polyester composites, Journal of Materials Science 1985; 20(11:4015-4020.

[7] S.Alok, S.Savita and Adityakumar, Study of mechanical properties and absorption behavior of coconut shell powder epoxy composites, International Journal of Materials Science Applications 2013; 2(5): 157-161.

[8] C.Girisha, Sanjeevamurthy and R.Gunti. Tensile properties of natural fiber reinforced epoxy hybrid composites. International Journal of Modern Engineering Research 2012; 2(2): 471- 474.

[9] PNE Naveen and M.Yasaswi, Experimental analysis of coir-fiber reinforced polymer composite materials, International Journal of Mechanical Engineering and Robotics Research 2013; 2(1): 10-18.

[10] PTR Swain and S.Biswas, Physical and mechanical behavior of Al2O3 filled jute fiber reinforced epoxy composites, International Journal of Current Engineering and Technology 2014; 2: 67-71.

[11] B.Sudhabindu, Static analysis and experimentation of jute fiber reinforced with E-glass. Applied Mechanical Engineering 2014; 1(1): 1-3.

[12] A.Mishra, Strength and corrosion testing of jute/ glass-epoxy hybrid composite laminates, Plastic and Polymer Technology 2013; 2(2): 48-54.

[13] S.Husseniyah, M.Mostapha, The effect of filler content on properties of coconut shell filled polyester composites, Malaysian polymer journal 2011; 6(1): 87-97.

[14] Pradhan, K.S, Dwarkadas, S.E., Reucroft, J.P., Processing and characterization coconut shell powder filled UHMWPE, Material science and engineering Journal 2004; 36791(20):57-62.

[15] Bledzki,A.K. and Gassan, J., Composite reinforced with cellulose fiber, Polymer science Journal 1999; 24 (1): 221-27.

[16] Sapuan,S.M., Harimi,M., & Maleque,M.A., Mechanical properties of epoxy/coconut shell filler particle composites, The Arabian Journal for science and Engineering 2003; 28(2B): 171-181.

[17] Joseph, P, V., Kuruvilla J, Thomas S., Composites science and technology 1999; 59(11): 1625-1640.

[18] Jain, S., Kumar, R., Jindal;, U,C., Mechanical behavior of bamboo and bamboo composites, Journal of Material science, 27: 4598-4604.

[19] Agunsoye J.Olumuyiwa, Talabi S. Issac, Sanni O, Samaual, Study of mechanical behavior of Coconut Shell reinforced polymer matrix composites, Journal of minerals and materials characterization and engineering 2012;11: 774-779.

[20] Bhaskar, Study of Physical and Mechanical Properties of Coconut Shell Particle Reinforced-Epoxy Composite, Journal of Materials and Environmental Science 2013; 4(2): 227-232

[21] Alok singh, Study of mechanical properties and absorption behavior of coconut shell powder-epoxy composites,

International Journal of Materials and Applications 2013; 2(5): 157-161.

[21] R. Udhayasankar, A Review on Coconut Shell Reinforced Composites, International Journal of Chem Tech Research 2015; 8(11): 624-637.

[22] Sarki J., Hassan S.B., Aigbodion V.S., Oghenevweta J.E., Potential of Using Coconut Shell Particle Fillers In Eco-Composite Materials, Journal of Alloys and Compounds 2011; 2381-2385.

[23] Nguong C.W., Lee S.N.B. and Sujan D. A Review on Natural fiber Reinforced Polymer Composites. International Journal of Chemical, Nuclear, Metallurgical and Materials Engineering 2013; 7(1): 33-39.