INVESTIGATION ON THE MECHANICAL PROPERTIES OF NATURAL FIBER COMPOSITES REINFORCED EPOXY WITH AL_2O_3 NANO PARTICLES

Babu K[1], Gnanavel babu A[2]
[1]Research Scholar, Department of Industrial Engineering, CEG Campus, Anna University, Chennai
[2]Asso.Professor, Department of Industrial Engineering, CEG Campus, Anna University, Chennai

ABSTRACT
Natural fiber based composites are becoming important materials in engineering fields. The composites are having enormous amount of advantages due to light weight, high strength to weight ratio and corrosion resistance. The endeavor of this project is to find out the Structural properties of newly identified Pandanus fiber (PF) and coconut bunch fiber (CF) composites which are consists of reinforced epoxy with Al_2O_3 Nano particles. The Pandanus fiber was extracted from the stem of screw pine tree by the manual water treatment process. Coconut bunch fiber was extracted from coconut bunch. The panels were fabricated by compression molding method with varying of weight percentage and length of fiber and compared with (NCF, NPF) & without Al_2O_3 Nano particles (CF, PF). Tensile, Compression strength, Impact energy, Hardness and Natural frequency of the composites were determined and plotted. The result value tends to increase strength of the panel with addition of Nano-particles compared without Nano-particles. The Pandanus fiber was much strong and reliable compared to the Coconut Bunch fibers. The most of the industries starts research of Natural fibers due to Cheep, recyclable and Bio-degradable materials.

Keywords: Pandanus fiber, Coconut bunch fiber, Epoxy resin, Al_2O_3 Nano particles, Tensile strength, Compression strength, Impact energy, Hardness and Natural frequency.

1. Introduction

Worldwide the natural fiber necessities have been improved among the people for house hold and industrial machinery products. Raw material was very cheap compared to other products because of easy identification and manufacturing of raw materials. Cost of the natural fiber was much more advantages to manufacturing of any type of composites with addition of epoxy resin. Most of the people are using natural fiber components to meet their basic necessity such as textile clothing, Housing and building materials. Whenever using the natural fiber it doesn't create any problem for the users and it also act as antibiotic drugs. Environmental, physical and mechanical alteration of the natural fiber reinforced recycled polymer composites, processing methods & improvements were discussed which also proved surface properties and adhesion between the filler & polymer matrix [1]. During processing the temperature sensitivity of the fibers that limits the time at temperature and its explained moisture removal stages was essential part of the manufacturing cycle [2]. Too many emerging technologies were introduced such as micro-braiding, long fiber pellet and textile insert molding. Natural fiber had high thermal resistance so that they can be included into high temperature engineering thermoplastics [3]. Natural fiber composite beams were stitched through the thickness which was arrest crack propagations on the plates and more energy absorption in comparison with non-stitched beams. It was also discussed hybrid composite beams bonded by stitching which were absorbed more energy in comparison with adhesively bonded composite joints [4]. Young's modulus and tensile strength of the nanocomposite were analyzed and observed the consequent improvements in the reinforcing ability of the nanocellulose in the rubber matrix. In NR matrix, three-dimensional network of cellulose nanofibers (cellulose/cellulose network and Zn/cellulose network) improved the properties of the cross linked nanocomposite [5]. Cellulose was extracted from borassus fruit fibers and characterized the raw fruit fibers and extracted cellulose by chemical analysis. The content of the cellulose was increased and decreased other than cellulose during the extraction process in the component which was given more effectiveness for the industrial applications [6]. Hygrothermal effects on natural frequency of fiber reinforced plastic composites and Basalt fiber reinforced composites were investigated with absorption of moisture or water content. Moisture content was highly presented in the composites which was reduced the strength and stiffness of the material. Basalt Fiber reinforced composites (BFRP) were affected due to weave pattern, thickness of the material, water absorption at various immersed conditions [7]. Based on the length, the fibers were prepared and fabricated by hand lay-up method. The flexural strength was more when increasing the fiber length consequently which was reduced for shorter length [8]. Bamboo fiber, banana fiber and linen fiber were investigated and analyzed. The result shown and proved that bamboo−banana epoxy resin composite shown better results compared to other fibers [9]. Wood dust reinforced epoxy composite were analyzed with different % filler wt. mechanical behavior was studied with different speeds of the composites. The properties were found in the composites it shown, up to certain limit of filler % was increased and then gradually decreased. The best mechanical properties were observed for 10 % filler wt. and speed of 1 mm/min and 2 mm/min speed [10]. Multilayer 3D green composites fabricated from Tururi fibrous material and investigated mechanical properties. It was found that composites with higher number of layers had lower normalized breaking load. Due to the stretch increment, resin penetration was improved and increased the normalized breaking load [11]. The goal of this research was to build up polymer composites from Pandanus and coconut bunch fibrous material and discussed method of fabrication and also investigates the tensile, compression, impact behavior properties and Natural frequency of the composites. PF has a few applications like clothing and medicinal for the animals and humans. CBF is also used for door panels & head liners in industrial related products.

2. Materials and Methods

Screw pine and Coconut bunch fiber, Epoxy resin(LY-556), Hardener (HY-951)Acetic acid, ethanol, sodium hydroxide (Merck Chemicals) Aluminium nitrate, Ammonia and de-ionised water were used to fabricate the composites and synthesis of Nano-particles (Al_2O_3).

2.1 Pandanus fibrous material Preparation (PF&NPF)

The Pandanus fiber is also called as Screw pine fiber. This is a natural fiber obtained from various portion of screw pine tree which is found in southern part of India. It’s mildly hardy and surveying to about 32-35F and produced large edible clustered fruit like a pineapple. The height of the tree is 15-25ft. The tree has form thickets of support root near the lower part of their trunks. In fig 2.1 Shown PF was collected from stem and extracted by water treatment process. The stem were crushed and flatted and then the fiber was separated from the root. Finally PF was cut in to required usage 30-35mm as shown in Fig 2.2.

Fig. 2.1 Pandanus Fiber source

Fig. 2.2 Extracted Pandanus Fiber

2.2 Coconut Bunch Fiber and Preparation (CF&NCF)

Coconut bunch fiber was prepared from the coconut tree bunch. The bunch were fully crushed and flatted by manually with hands and fiber was separated from the roots which length was taken 30-35mm and bunches it to prepare for the composites. The extracted fiber and Coconut bunch as shown in fig 2.3(a) & (b).

Fig. 2.3. Pictorial view of (a) Coconut bunch fiber source and (b) Coconut bunch fiber.

2.3 Bonding Materials

PF and CF composites were fabricated by using polymer resin materials which were Epoxy resin(LY-556) and Hardener (HY-951) as shown in fig 2.4. They were waxed and pre accelerated suitable for both hand lay-up and gun spray-up. The resin has a so much of applications to making a fiber reinforced composites and products such as boats, telephone booths and bus shelters.

2.4 Nano Particles (Al_2O_3)

The chemicals Aluminium nitrate, Ammonia and de-ionised water were used as preliminary. When ammonia (3.4%), Al cations were precipitated at *pH* ~7.3–8.5 and Al nitrate salt solutions were mixed together in 400 ml de-ionised water. The solution was mixed under ultrasonic vibration and maintained at temperature 70 ºC for 2 hrs. The following different chemical reactions were occurred during the preparation:

$$Al\,(NO_3)_3 + 3NH_4OH \rightarrow Al\,(OH)_3\downarrow + 3NH_4NO_3 \quad (1)$$
$$Al\,(OH)_3 \rightarrow AlOOH\downarrow + H_2O \quad (2)$$
$$AlOOH \rightarrow Al_2O_3 + H_2O \quad (3)$$

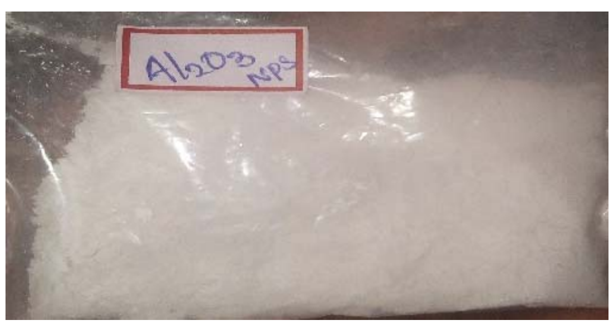

Fig. 2 Photographic view of Al_2O_3 Nano particle

Due to the reaction (1) the precipitate was obtained and it was aged at a temperature of 70 ºC also helped to homogenize the gel. Al $(OH)_3$ was converted into to crystalline boehmite precursor by reaction (2) at ageing. de-ionised water was used for washing the precipitate and added with 300 ml ethanol to the filtered Al $(OH)_3$ under ultrasonic vibration for 1 hr. then it was dried in oven at 70 ºC for 18 hrs. Al_2O_3 was produced by calcinations of dried boehmite (AlOOH) at 550 ºC for 4hrs by reaction (3) and Fig 2 shows the synthesised Al_2O_3 Nano particles.

2.4 Method of die Preparation

Die plates were made up of Cast Iron block with the size of 500x500x25mm two plates. Surface of the plates were silver coated to get the good surface finish of composites and restrict the air bubbles present in the composites.

2.5 Method of Composite Preparation

There are different types of methods to fabricate composites fiber with combination of any material. The new identified fiber with the polymeric materials was fabricated by hand layup method. The fabrication method needs more concentration when fabrication of composites. Die plates were cleaned with oil to remove the unwanted debris's present on the die setup. The fibers were washed with clean water and parched on pan. Epoxy resin poured in to the bowl and kept on the stirrer table which is stirred 5minutes to get the even mixture of resin. Then hardener was added in to the resin to increase the bonding capability and easy dehydration. The solution was stirred again 5-10 minutes for even mixture and kept separately. Dehydrated fibers were arranged in random manner on the bottom die plate as per standard (200x200x3.5) and mixed resin was poured on the fibers. Resin was spread over on the entire place of fiber which has gets wet condition otherwise the round pipe was rolled on the fiber to get even resin and fiber formation which is also removed the air bubbles from the composites. After some 5minutes closed fiber contents with top plate and given hand pressure to get even closing of die plates. Then it's opened after 4 days the composite plate was made as a thin plate with standard the size. The above procedures are repeated to make the different composite plates of CF, NCF, PF and NPF. If no of days are increased to open from 4 to 7 days moisture content completely removed then no need of dehydration otherwise moisture content 99% only will be removed from the plates. The table shows the preparation details of Composite of samples CF, NCF, PF and NPF.

Table 1 Composite of samples CF, NCF, PF and NPF

Sl.No	Orientation	Composition	Volume (%)
1	Random	Epoxy resin, Hardener & Coconut bunch fiber (size-30−35mm)	85/5/10
2	Random	Epoxy resin, Hardener, Coconut bunch fiber (size-30−35mm) & Al_2O_3 Nano particles	82/5/10/3
3	Random	Epoxy resin, Hardener & Pandanus fiber (size-30−35mm)	85/5/10
4	Random	Epoxy resin, Hardener, Pandanus fiber (size-30−35mm) & Al_2O_3 Nano particles	82/5/10/3

3. Results & discussions

3.1 Tensile Test Results

The mechanical properties of laminated composites have been carried out for the CF&PF with addition of Nano-particles. Tensile test was studied on the two laminated composites (ASTM D638- 165 x 13 x 3mm) which is given high tensile of PF compared to the CF. Addition of Nano-Particles also given improvement value of composites but the Pandanus fiber Nano particle fiber composite was given the high value of tensile compared to the other composites shows the Fig 1. Al_2O_3 Nano particles are increased their properties with mixing of fiber and polymer slightly and also increased the hardness of composites. Based on the Mixing ratio of Epoxy and hardener was given acceptable bonding capability of the composites to improve the tensile and compression properties. Fiber contents are more in that area such place was observed high strength properties of the composites. Initial Crack was propagating at the place of less fiber content present in the composites. The results of the Pandanus fiber was increased the tensile properties 12.22Mpa after addition of Nano particles and the present cases normally the PF Composites was determined high tensile properties which was compared to CF composites and it was 9.47Mpa probably increasing of 9.7%.

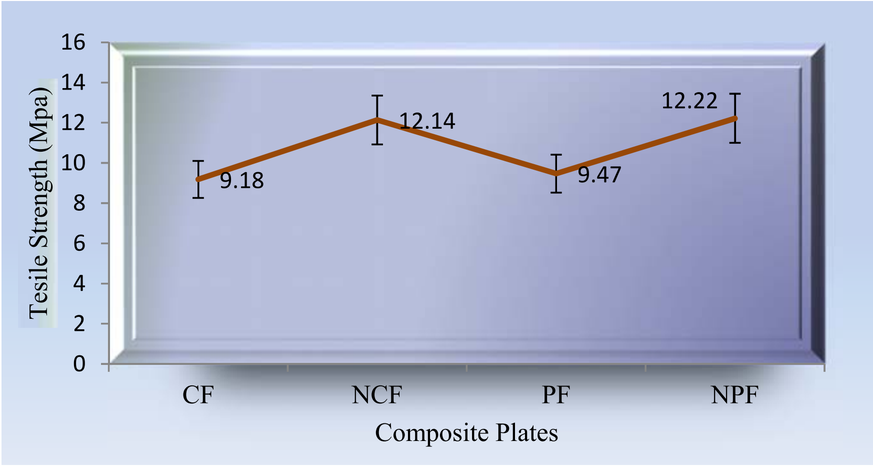

Figure 3.1 Tensile strength of Composites

3.2 Flexural Test results

The Flexural test is carried out on the four different composite plates (200 x 30 x 3mm) with addition of Nano Particles. The variations of flexural load of the composites are shown Fig 3.2 and tested as per the ASTM D790. It shows clearly NPF composites observed high flexural load 0.24kN compared with other composites. Fig 3.1 shows various loads with deflection rate of the different composites. All the composites are started gradual increasing and then the deformation rates are shows more.

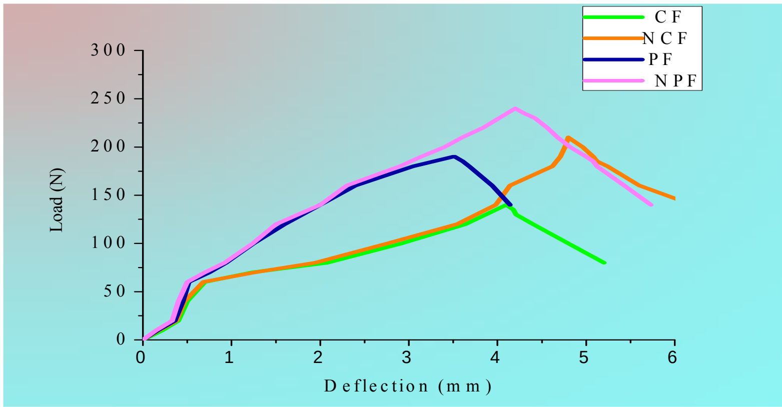

Figure 3.1 Bending tests of Composites

The precipitation of Nano particles was given slight improvement of the composites which was given higher strength properties. At higher percentage (>5%) of Nano particles present in the composite which drop the tensile and compressive properties.

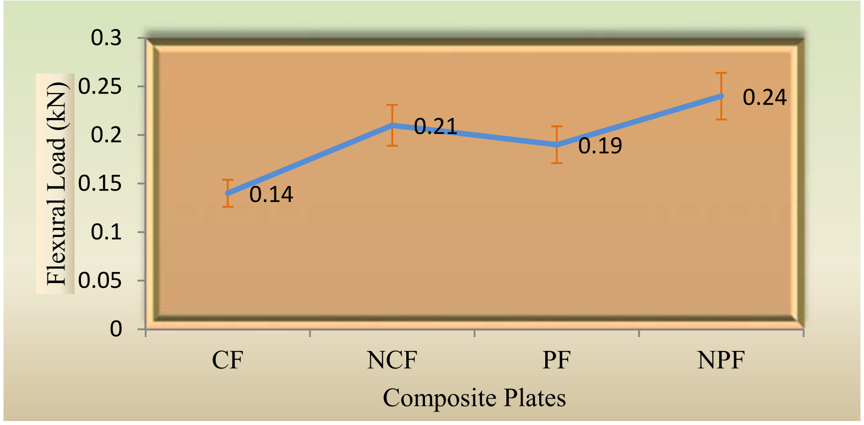

Figure 3.2 Flexural Loads of Composites

The Flexural strength and Flexural modulus are shown in the Fig 3.3 which is observed higher value of composites with addition Nano particles about 3wt%. The flexural modulus graph was gradual increasing of composites but the flexural strength was deviated from normal gradual increasing and drops the value of PF composite plate compared to the NCF due to improper alignment of fiber content.

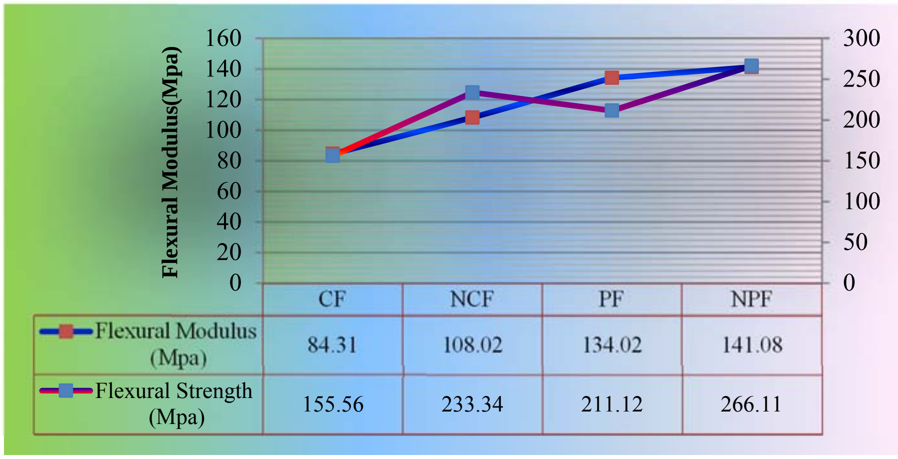

Figure 3.3 Flexural Properties of Composites

$$\text{Flexural strength}= \frac{3FL}{2bd^2}$$

F-Flexural Load, L-Length of the specimen, b-breath of the specimen, d-depth of the specimen.

$$\text{Flexural modulus}= \frac{mL^3}{4bd^3}$$

m=slope, L-Length of the specimen, b-breath of the specimen, d-depth of the specimen.

3.3 Impact Test Results

Impact test are mostly carried out on the polymeric composites to analyze damage properties and energy absorption during the fracture. The test is more important for analyzing the lifetime of the material and product safety. In this test, NPF composites was absorbed more energy compared to the other composites due to strength of fiber and Nano particles present and also even dispersion in the composite plates. The Fig 3.4 shows the maximum energy absorption rate.

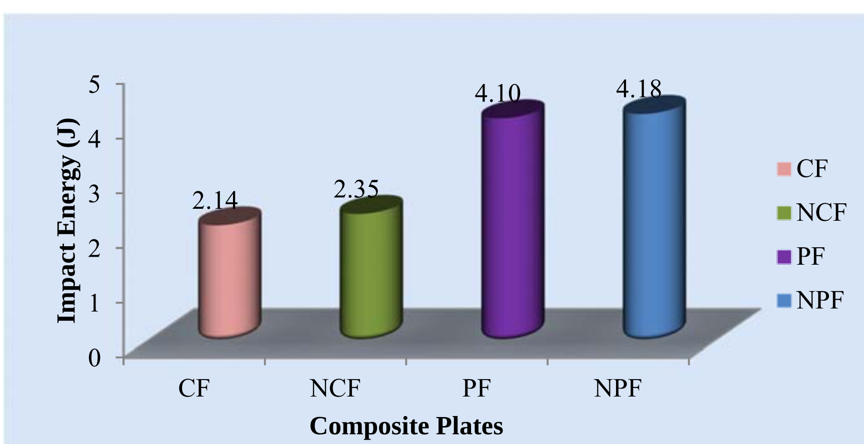

Figure 3.4 Impact Energy of Composites

3.4 Hardness Test

In Fig 3.5 shows the hardness of the various composite plates. CF was less value compared to the other composites because of strength of the fiber and content present**.** NPF Composites gets higher value 568 HRC due to addition of Nano particles present in the plates. The gap between the fibers also desired the mechanical properties if it's having a less gap the bonding capability is improved between the fiber and polymer resin**.**

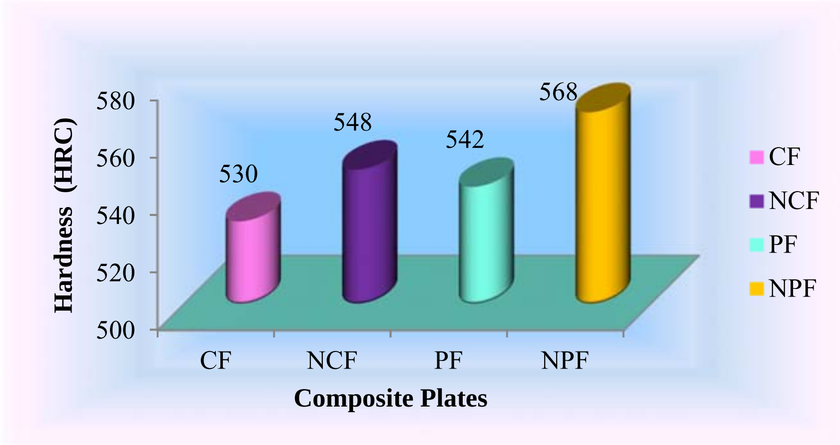

Figure 3.5 Hardness of Composites

3.5 Natural frequency

The frequency of the polymer composite materials is based on the deflection which is measured perpendicular to the plate axis. It gives the less vibration and easy to transmit it, to the environmental so that the failure of the product to be reduced. PF was observed more frequency level which is leads to fracture of composites. If the deflection is high the frequency is move to less value as explained in the Fig 3.6.

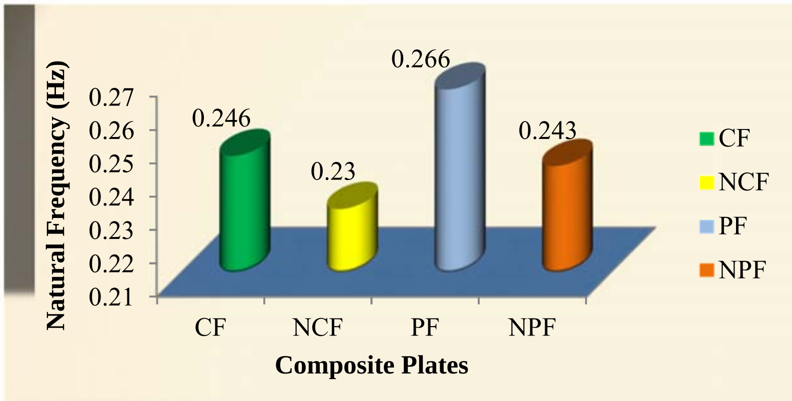

Figure 3.6 Natural frequencies of Composites

4. Conclusion

The mechanical properties of CF, NCF, PF and NPF reinforced epoxy composites are studied with addition of Nano particles. The experimental results support that the successful addition of Al_2O_3 Nano particles in NCF and NPF reinforced epoxy composites is possible to fabrication. The PF and NPF composite have given good tensile properties other than CF and NCF. The flexural strength of the PF composites slightly decreased comparison of NCF and the flexural modulus of PF and NPF composites is higher than the CF and NCF reinforced epoxy composites. The NPF reinforced epoxy composite was observed that the higher mechanical properties. In future we are going to carry out the test with Variety of Nano particles addition and increasing of different % of Nano particles with CF and PF fibers.

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