Synthesis, Testing & Characterization of Epoxy-CNT-Bamboo Polymer Matrix Hybrid Composite

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Abstract - *The present ongoing energetic human race can't visualize its progress without bringing the conception of development in composite materials. An assortment of researches is occurring in this field to achieve the desired standard. Natural fiber reinforced polymer composite has a vast resemblance to substitute the composite made up of synthetic fiber. This is principally because of the several benefits of composites like light weight, in-toxic, in-abrasive, ease of use, low expenditure, and eco-friendly properties. The synthetic fibers have superior end of mechanical properties like tensile modulus & tensile strength nevertheless the specific mechanical properties like specific tensile modulus and other specific properties (properties/specific gravity) of natural fibers give a pleasing outcome for composites comparing to synthetic fiber based composites. The aim of the present study is to examine the mechanical attributes of bamboo fiber & CNT reinforced epoxy based composites. Bamboo fibers with varying percentage of CNT are reinforced in epoxy resin to manufacture composite materials. The outcome of bamboo fiber and CNT content on the mechanical behavior of composites has been studied.*

Key Words: CNT

1. INTRODUCTION

The usage of natural composite materials has been a part of man's engineering, science since the first antediluvian builder used straw to reinforce mud bricks. The 12th century Mongols made the upgraded weapons of their day with archery bows that were smaller and more herculean than their rivals. These bows were composites structures made by conflating cattle tendons, horn, bamboo and silk, which bonded with natural pine resin. The tendons were stationed on the tension side of the bow, the bamboo was practiced as a core and sheets of horn were laminated to the compression side of the bow. The integral structure was tightly enwrapped with silk using the rosin adhesive. These 12th century weapons designers surely interpreted the principles of composite design. In recent times, some of these 700-year old museum pieces were threaded and examined. They were about 80% as potent as modernistic composite bows. In the late 1800s canoe builders were trying out with gluing together strata of Kraft paper with shellac to form paper laminates. While the concept was successful, the materials did not execute well. Because the useable materials were not up to the job, the idea languished. In the years between 1870 and 1890, a revolution was happening in chemistry. The first synthetic (man-made) resins were explicated which could be commuted from a liquid to a solid by polymerization. These polymer resins being transformed from the liquid to the solid by crosslinking the molecules. Ahead of time synthetic resins included celluloid, melamine and Bakelite. Composites are no longer regarded "space-age" materials employed for concealment bombers and area shuttles. This adaptable material system has become a part of routine life. In fact, composites are so widely practiced and in such wide-ranging of diligences, the overall composites market had to be shared out in the pursuing major commercial sections to traverse its thousands of products. The major areas which are being covered by Composites are- Aircraft/Military, Appliance/Business, Automotive/Transportation, Civil Infrastructure, Construction, Consumer, Corrosion-Resistant Equipment, Electrical, Marine. Polymers are comprised of exclusively molecules that gives the formation of long chains Macromolecules is the name that we represent it. Polymers are the substances which have the reiterating units which recur and recur to give the formation of long chains, called monomer. These monomeric units are very large in number repeating continuously, each sample of a granted polymer being characteristically a blend of molecules with several molecular weights. The scope of molecular weights is sometimes quite constricting, but is more rather very wide. The special material properties of polymers and the adaptability of their processing methods are assigned to their molecular structure. For various purposes, the easiness with which polymers and plastics being processed makes them the most looked for material today. Because of their comparatively low density and their property to be shaped and moulded at comparatively low temperatures compared to traditional materials such as plastics, metals, and polymers are the materials of alternative when incorporating various parts into a single component - a design prospect usually called part integration. Composite materials comprise of matrix & reinforcement. These comprising phases of composite are sized in the macro levels of the constituting portion, which are different to each other and insoluble too physical & chemical form respectively. This insolubility gives result to getting properties fair to their proportion. Most of the matrixes we see are weaker than their reinforcement. Specific property of matrix is to hold reinforcement in the aligned positions as conjugate entities. Matrix protect reinforcement from external environment factors, get slow the process or ending the crack propagation. And the reinforcement acts the entire load bearing material in the composite. By analysing the way to the composite degradation they can be biodegradable and degradable as well. Bone, which is a natural composite material, consists mainly of collagen fibres and an inorganic bone mineral matrix in the form of small crystal called apatite[1]In the present era of environmental consciousness, more and more material are emerging worldwide, Efficient utilization of plant species and utilizing the smaller particles and fibres obtained from various lignocellulosic materials including agro wastes to develop eco-friendly materials is thus certainly a rational and sustainable approach. Biodegradable plastics and polymers were first introduced in 1980s [2]. Biodegradability also depends on the type of fibre reinforcement usage as natural fibre in place of synthetic fibre. Nowadays natural fibres form an interesting alternative for the most widely applied fibre in the composite technology, the use of fibres like bamboo, hemp, jute or sisal is small for availability of a durable semi-finished product with constant quality is often a problem. Recent research and development have shown that these aspects can be improved considerably. Knowing that natural fibres are cheap and have a better stiffness per weight than glass, which results in lighter components, the grown interest in natural fibres is clear. Secondly, the environmental impact is smaller since the natural fibre can be thermally recycled and fibres come from a renewable resource. Their moderate mechanical properties restrain the fibres from using them in high-tech applications, but for many reasons Natural fibres can compete with glass fibres [2]. For the past several years, public attention has gone to natural fibres as a resource due to their fast growth. Bamboo is an abundant natural resource in Asia and South America, because it takes only several months to grow up. It has been traditionally used to construct various living facilities and tools [1]. The high strength with respect to its weight is derived from the fibres longitudinally aligned in its body. Therefore, bamboo fibres are often called "natural glass fibre". To practically apply the benefit of bamboo fibres, it is necessary to develop a process to fabricate bamboo composites as well as to extract qualitatively controlled fibres from bamboo trees. However, it is difficult to extract, bamboo fibres having its superior mechanical properties. The bamboo fibre is often brittle compared with other natural fibres, because the fibres are covered with lignin. Therefore, a devised process should be adopted to extract the bamboo fibres for reinforcement of composite materials. Several studies have already been executed on the study of bamboo fibre reinforced composites using thermosetting plastic (epoxy and polyester) showed the tensile, bending and static strength of the composite reinforced by bamboo strip mats.

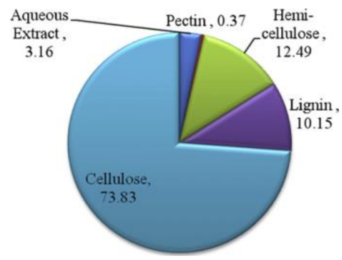

Fig -1: Chemical constituents of Bamboo fiber [4,5]

Plant fibers consist of 7 categories, viz. seed, bast, leaf, fruit, stalk wood, and grass fibers [6]. Bamboo comes in the grass householdBambusoideae, which is having cellulose fiber implanted in a lignin matrix [7,8]. Bamboo has various benefits over the other plant fibers such as its low density, high mechanical strength, low cost, stiffness, eminent growth rate and its power to fix atmospheric carbon dioxide [9-13]. Bamboo also has more or less disadvantages for several diligences, letting in high moisture content, the trouble of taking out very well and straight fibers, and thermal abjection while manufacturing [11,14]. More than 1000 varieties of bamboo and approx. 70 genera grow in the natural conditions in diverse climatic condition, having specific plentiful amount in Asia and South America [15,16]. Bamboo has normally having usage in construction and as a material for the manufacturing of tools for daily usage because of its eminent strength to weight ratio. Several varieties of species of bamboo having different mechanical properties & geometric shapes and, having result that raw bamboo can't touch the needs of commercial production [17]. Several studies have been conducted out to make bamboo fiber-reinforced composites with convenient mechanical properties by means of different extraction procedures and providing in the bamboo in a diversity of resins. The mechanical properties of bamboo fibers formed as engineered materials are measured comparable with that of glass fibers. As bamboo fibers in the culm are ordinated in longitudinally, they are called 'natural glass fibers'. The useable works on bamboo suggest that this sort of natural plant having potency to be practiced as a strengthened polymeric composite material. Even so, it is hard to draw out bamboo fibers with consistent length and higher-up mechanical properties. Hence, many surveys have been carried out to pull out the desired fibers in a manipulated manner. Bamboo culm incorporates a eminent % of amorphous lignin, roughly 10.15%, and 73.83% cellulose. Nevertheless, these quantities differ in various bamboo species. This higher lignin contentedness makes the bamboo fiber brittle in comparing to other natural plants. Based on its particular properties i.e. specific strength, stiffness & low density bamboo fiber being compared with the glass fiber for diligences in composite materials. Bamboo fiber has been utilized in dissimilar structural uses and for several commercial-grade purposes. Lately, the purpose of bamboo fibers as strengthened polymer composite materials have got increased because of innovative processing technology [16,18,9,12,19,20]. Since Iijima's story on CNTs in 1991 , scientists have been drew in by CNT's alone atomic structure and attributes, like high strength-to-weight ratio, high aspect ratio, exceptional mechanical properties (tensile strength & axial elastic modulus were theoretically prefigured to be as eminent as 200 GPa and1-2 TPa1-2 TPa , respectively), master thermal and electrical properties (thermally static up to 2800°C in vacuum or torpid atmosphere, thermal conductivity almost twice as higher as diamond, & electric-current-carrying capability 1000 times higher than the copper wires). These properties of CNTs empower themselves with newly scientific and technical chances as an idealistic filler material in the composites. Until now, several composite materials have been devised by comprising Single Wall Nano Tubes(SWNTs) & Multi Walled Nanotubes (MWNTs) into a metal matrix, a polymer matrix or a ceramic matrix. Polymers can be well treated and manufactured into elaborately shaped elements without injuring CNTs while treating applying conventional means, and therefore the manufacturing price can be surely cut. Consequently, CNT based polymer composites (CNT/polymer composites) induce heavy concerns and have been extensively examined. Giovanni Belingardi et al. (2001) studied specific glass-fiber-epoxy matrix laminates together with unidirectional layers and with woven layers sequencing, with three various layers' orientations.

1.1 Literature Review

Investigational tests are conducted according to ASTM standards using a free-fall drop dart testing machine with two energy absorption factors (namely saturation impact energy and damage degree), two significant attributed values of the impact force history (the first damage force and the maximum force) and the sensitivity of the material mechanical properties to the strain rate effect are taken for the describe the impact behavior of the material [35]. Ming Qiu Zhang et al. (2001) studied effect of particle surface treatment on the tribological performance of epoxy based Nano composites an irradiation transplanting method was employed to vary Nano silica by covalently bonding polyacrylamide (PAAM) onto the particles. When the grafted Nano silica was summed to epoxy, the solidifying kinetics of the matrix was quickened and got the outcomes that sliding wear tests of the materials established that the frictional coefficient and the particular wear rate of Nano silica/epoxy composites are lower than those of the unfilled epoxy [40]. Ajith Gopinath et al. (2014) studied Experimental Investigations on Mechanical Properties of Jute Fiber Reinforced Composites with Polyester and Epoxy Resin Matrices. In this investigation, fiber reinforced composites were arranged with jute fibers of fiber length 5-6 mm. The resins utilized in this study are epoxy and polyester. The composites were manufactured at 18:82 fiber-resin percentages of weight. The formed composites were examined to learn & analyze the mechanical properties of the composite which are flexural strength, tensile strength, hardness and impact strength. 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(2016) studied Natural fiber-mediated epoxy composites and concluded the following things that the main aim of this review is to learn the formulation, features and performance of several cellulosic fiber famed epoxy composites, hence to offer the fundamental origin for advance research in the area and to allow the optimization of the composites for probable industrial applications. Plenty of reports are available on natural fiber epoxy based composites and their characteristic analysis [41]. Add-on of fibers impresses the polymer composite matrix in two ways. Firstly, it scales down the composites costs and raises the composites properties Biswas and Satapathy [32] analyzed the loading of red mud on the mechanical features of the bamboo fiber/epoxy composite and matched with the similar set of glass/epoxy composites. They have accounted that the mechanical strength of bamboo fiber composite is lesser than the glass reinforced epoxy composites while wear properties are higher-up to the glass/epoxy composites. Both properties are advance raised by the accession of red mud content in both the composites [32]. Nirmal et al. (2012) looked into the determination of fiber orientation on the wear and fractional attributes of the bamboo fiber/epoxy composites. They found in their study that anti-parallel orientation of the bamboo fiber composite has a sound adhesive wear performance (bettered by 60%) than any other orientation. Frictional performance is also more well for an anti-parallel orientation of the bamboo fiber composite at low sliding velocity [44]. Rosa et al. (2010) analyzed the impression of fiber orientation on the thermal features of the phormium tenax fiber/epoxy composites. Composite of phormium tenax fiber and epoxy displays to a greater extent thermal stability as compared to fiber and epoxy resin individually [45]. Lu et al. (2013) tested the determination of sodium hydroxide and saline treatment on the mechanical conduct of the bamboo fiber/epoxy composites. It was observable from their work that alkali processed fiber composites gives 31% rise and 34% rise in tensile in elongation at break, nevertheless saline coupling agent processed composite gives 53% rise in elongation & 71% rise in tensile at break [46]. Yeng-Fong Shih (2006) studied the mechanical and thermal properties of waste water bamboo husk fiber reinforced epoxy composites. In this work, the fibers received from water bamboo husks were chemically altered by coupling agents. Furthermore, the powders received from water bamboo husks were also employed, but without chemical alteration. Moreover, the changed fibers and unprocessed powders were respectively, summed to epoxy resin to cast fresh reinforced composites. Sound structures, mechanical properties and heat resistivity of the water bamboo husk reinforced composites were looked into. The outcomes show that the fiber is cellulose I type. The morphology analysis brings out that the fibers altered by coupling agents showed more well compatibility with the polymer matrices than the unprocessed fibers did. Furthermore, the thermal resistivity was bettered as the plant fibers and powders were separately integrated to those polymers. Additionally, the mechanical properties were also raised due to the add-on of coupling agent processed fibers and untreated powders. The growths of storage moduli of epoxy were about 16.4 and 36.1% with the summation of 10% coupling agent processed fibers and unprocessed powders. J-H. Du et al. (2007) explained the present position & central problems of carbon nanotube based polymer composites. Looking on the outcomes being highlighted up till now, CNTs can be an effectual reinforcement for polymer matrices, and elastic modulus & the tensile strength of CNT/polymer composites can attain as eminent as 3600 MPa and 80 GPa, respectively. CNT/polymer composites are also assuring functional composite materials with amended electrical and thermal conductivity, etc. Because of their multi-functional properties, CNT/polymer composites are anticipated to be used as low weight morphological materials, optical appliance's, electric components, thermal interface materials, electromagnetic soaking materials, etc. Nevertheless, the full potential of CNT/polymer composites still stays to be actualized. A few key troubles, such as how to develop structure controllable CNTs with high pureness and systematically reliable high performance, how to break up embroiled or bundled CNTs and then properly scattered and adjust them inside a polymer matrix, how to improve the load transmit from matrix to CNT reinforcement, etc., still subsist and demand to be figured out in order to recognize the wide applications of these modern composites [43]. Zilli et al. (2005) studied Epoxy matrix composites have been developed utilizing as filler unlike weight fractions (0.03–1 wt. %) of chemical vapor deposition (CVD) produced multi-walled carbon nanotubes (MWCNTs) carrying entrapped iron nanoparticles. Magnetic characterization executed at room temperature having magnetic field in between - 19 and 19 kG displays that the Nano composites are feeble ferromagnetic at room temperature. A sharp fluctuation in the habituation of both the coercively field, and remnant magnetization with the weight fraction of MWCNTs, answers indicate the constitution of MWCNTs agglomerates for rising weight proportions, in accordance with SEM micrographs [39].

2. EXPERIMENTATION

Matrix material used in this case is the Epoxy. Epoxy is a thermosetting polymer. Matrix material used in this case is the Epoxy. Epoxy is a thermosetting polymer. Thermosetting plastics or are constituted with a mesh of molecular structure of primary covalent bonds. Various thermosets are cross-linked by heat or a compounding of heat & pressure. Others may have been cross-linked by chemical reaction, which happens at room temperature. Epoxy resins are the most readily used thermoset plastic in the composites having polymer matrix. Epoxy resins have low cure shrinkage because they are the family of thermoset plastic materials which usually not give off reaction products when they cure and so have low cure shrinkage. They also have fair adhesion to other materials, good chemical properties and good insulating properties good chemical and environmental resistance. The epoxy resins being usually fabricated by reacting epichlorohydrin with bisphenol. Various resins are being made by varying ratios of the two: as the proportion of epichlorohydrin is reduced the molecular weight of the resin is given increment. Epoxy resins are being cured by way of a curing agent, frequently referred as catalysts, hardeners or activators. Here, Epoxy hardener (HY-951) is used for the curing. Fiber material we used in this Natural Fiber reinforced composite is the Bamboo fiber. Afresh (not dry) bamboo was purchased from the local market in Bhopal. Then, fine strips of thickness 1.5 mm were extracted, cut & assembled to form into mat form of 13.5mm × 14.5mm. Then these mats were left for being died & get dried for a week. Filler material used here is CNT (Carbon Nano Tubes). In order to increase the strength conductivity of polymer matrices of the composite the varying percentage of the CNT is used and further samples were made. The list of equipment's, machines and raw materials used for fabrication and testing of the Nano composites and hybrid composites are, Epoxy (LY-556), Hardener(HY-951), Carbon Nano tubes (CNT), Bamboo Fiber woven mat, Acetone, Mould Relief Agent, Borosil glass beakers, Mild steel shoulder die, Mild Steel plate die, Muffle Furnace, Magnetic Stirrer, Mechanical Stirrer, Ultrasonic Bath, Nitrogen Gas, Weighing Balance, Universal Testing Machine, Atomic Force Microscope(AFM), Izod and Charpy impact tester. Prior to the making of polymer composite reinforced with bamboo & CNT, the bamboo mats were given chemical treatment. Alkali treatment was given to the fiber in order to gain better fiber matrix interactions & bond strength. For the chemical treatment a 2 Litre beaker, NaOH, distilled water was used. 2 wt. % of NaOH to the total weight of the bamboo mat is taken & 1 litre of distilled water was then poured in the beaker and NaOH is being mixed. Then the Bamboo mat is dipped thoroughly and kept for 3-4 hours. After this time frame, the Bamboo mat is being kept in the furnace for 5-6 hours and the temperature is increased slowly to 80 ^{o}C and maintained for the rest of the time. After this much of time frame ejection of the bamboo mat from the furnace is done and complete ejaculation of moisture from the fiber is being achieved and ready for use. For the proper making of the composite sample the according to the die in the hand layup process amount of Epoxy taken is 200 gm. & weighed in the weighing machine. To get varying samples according to the need, the percentage variation of the CNT is done as 0%, 1%, 2%, and 3% and weighed at the time of making samples separately at the weighing balance. According to the weight of the bamboo mat the percentage 2 % of NaOH is taken and weighed and after mixing it with the distilled water is being mixed and the bamboo mat is dipped and kept for 3-4 hours. And then in the furnace heated for another 4-5 hours to get its moisture removed completely and ready to use. In each sample 1 bamboo fiber mat is fixed. The Epoxy resin after being taken 200gm is being heat treated to decrease its viscosity. It is being stirred on the magnetic stirrer at 80˚C for continuous 1 hour at 400 rpm. For the 0% CNT sample the Epoxy after being heat treatment used as it is & for the 1%, 2%, 3% variation percentage of CNT after epoxy heat treatment the CNT is being poured slowly into the beaker so that magnet rotating inside gets it mixed in the solution thoroughly. The temperature is being maintained at 80˚C for another 1 hour and rotation maintained about 600 rpm. After this the mixture is placed in ultrasonic bath for 30min which is maintained at 80°C for uniform dispersion of CNT. After stirring gets completed the mixture is degassed for 5-7 min by passing nitrogen gas. After this, magnetic stirrer is being monitored to 0˚C & rpm remains the same. The mixture is made to attain the room temperature. After this the 15mL approx. of Acetone is being mixed in the mixture and mixed in the magnetic stirrer at 0˚C at 600 rpm for 1 hour. Once the mixture reaches to the room temperature, hardener (HY-951) is mixed in the ratio of 15:1, i.e. in 200gm of epoxy 12.5gm of hardener is added. As the reaction after adding the hardener is exothermic it emits heat and starts getting hard in next 10 to15min. Dies are preheated and then a coat of mould relief agent is applied on the inner surfaces of the die to facilitate easy removal of a sample after curing. Now the mixture along with the hardener is poured into the die, then the bamboo layer is fixed in the die with the help of the hand roller and above that rest of the mixture is poured. And then when solidification starts the upper plate is closed and the lower and upper die is screwed. Then both the dies are left for 10 to 12 hrs. Curing at room temperature and then the samples are removed from the die. The sample plate is then cut in the desired dimensions according to ASTM standards with the fiber cutting machine.

2.1 MECHANICAL PRPOERTY TEST

2.1.1 Tensile Test

Tensile test were carried out using INSTRON-3382 machine, at Central Institute of Plastics Engineering and Technology (C.I.P.E.T.), Bhopal. Tensile test specimens were developed according to ASTM D638 tensile sample specification for polymer and plastic materials. The specimen compasses a cross section of 160mm x 25mm x 3mm. The tensile check was distributed on the UTM that encompasses a capability of 100 KN and continuing gauge length of 150mm. Length of 115.00000 mm, rate at 50.00000 mm/min, Temperature 25˚ C, Humidity 55 % was maintained throughout the experiment.

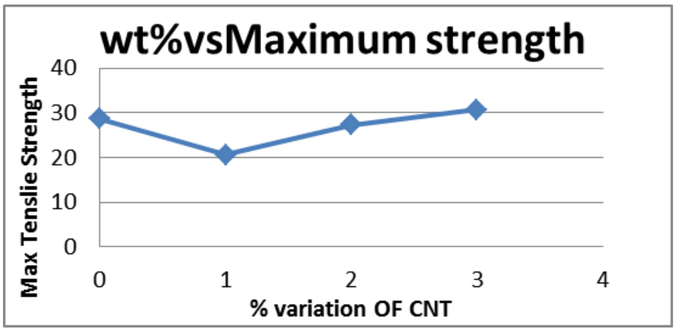

Chart -1: Variation of %CNT in bamboo epoxy with maximum tensile strength in MPa

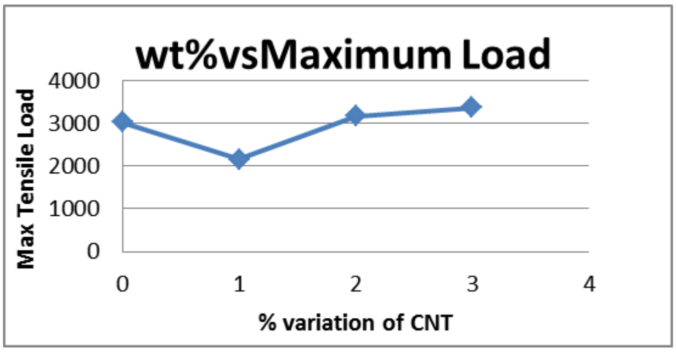

Chart -2: Variation of %CNT in bamboo epoxy with maximum tensile load in N

The results outcome in the tensile testing of the standard samples of different percentage variation shows that, the trend of decrement of the tensile load & the strength is seen. After that the results of load & the strength followed the increase trend. This shows that after the CNT reinforcement the results have gone down but also have gone up as the percentage increase in CNT in the hybrid composite. These outcomes give a major role play of the Bamboo fiber mat in between; the interface of the composite is such that it is helping in the increment of the tensile strength the resisting load. It can also be seen that percentage variation of CNT is playing a major role, because the readings of the 3% CNT+ Bamboo + Epoxy is crossing the readings of Epoxy + Bamboo. Therefore, in order to give more tensile strength, the percentage variation is needed in higher amount in this composite.

2.1.2 Flexural Test

Flexural test were conducted on INSTRON-3382 machine, at Central Institute of Plastics Engineering and Technology (C.I.P.E.T.), Bhopal. Flexural test specimen was developed according to ASTM D790 flexural sample specification for polymer and plastic materials. Flexural Test Conditions were maintained at Length 115 mm, Temperature 18°C, Humidity 50%. Flexural strength of the composite was calculated using the relationship.

$$f = 3PL/2bt^2$$

f = stress within the outer specimen at Centre, P = load at a given purpose on the load deflection curve, L = support span, b =dimension of the sample, t = depth of the sample

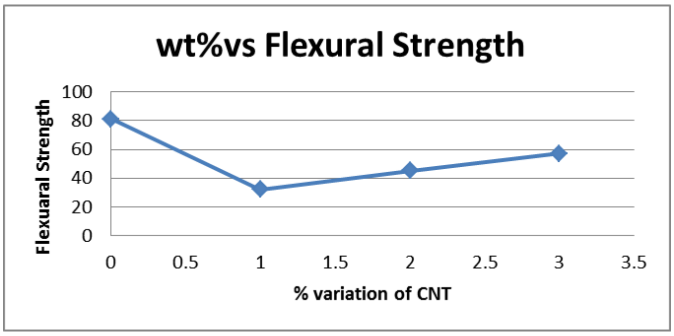

Chart -3: Variation of %CNT in bamboo epoxy with maximum flexural strength in MPa

The results of the Flexural test show that while testing the sample Epoxy + Bamboo the bending stress developed is more as compared to sample in which CNT is added as it is making it brittle. Sharp decrease in the strengths is being noticed from the Epoxy + Bamboo sample to 1 % CNT+Bamboo+Epoxy sample. After that the readings have gone up due to CNT+Bamboo reinforcement the strengths have gone higher but it is still less than the Epoxy + Bamboo sample.

2.1.3 Impact Test Results

Impact testing (IZOD test) of the polymer samples were done on Izod and Charpy Impact Tester, Tinius Olsen, USA available at CIPET, Bhopal. The impact specimen's area unit ready in line with the quality ASTM D256. The specimen encompasses a cross section of 64.5mm x 12.7mm x 3.2mm. The impact check was distributed on the Izod Impact Testing Machine that encompasses a capability of 25 Joules. This check provides United States the number of energy absorbed by every specimen the specimen was clamped into the tester and therefore the apparatus was free from a height to strike the specimen. The corresponding values of impact energy of various specimens were obtained directly from the dial indicator.

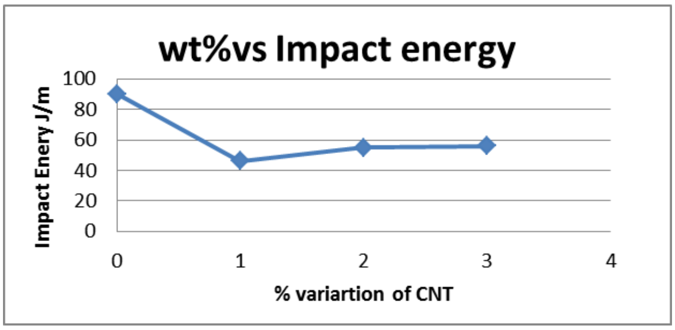

Chart -4: Variation of % CNT in bamboo epoxy with maximum Impact energy (J/m)

The impact tests result shows that Epoxy + Bamboo sample due to no reinforcement has more impact strength as the energy absorption is higher as compare to the 1%, 2%, 3%CNT+ Epoxy + Bamboo samples. The interpretation is clear that brittle character is coming into play after adding of the CNT in the Epoxy + Bamboo sample. But, due to the bamboo interface in CNT variation samples the impact strength has gone a little higher.

2.2 Mechanical Characterization

2.2.1 AFM (Atomic force microscopy)

In the conducted AFM the grain analysis of the Nano particles was done for each percentage variation separately. Various pictures were obtained showing the grains & the respective grain boundaries. Orientations of the Nano particles were also seen in the 3D picture view for a section of the sample. No. of grains i.e. the Nano particles here in this case the CNT is obtained for various 1 %, 2%, 3% percentage separately. And in the grain analysis the various parameters were obtained as diameter, length, Average size, grain no., Volume etc. We can see for different variation the pictures and the graphs plotted for the frequency counts of the grains with respect to length, diameter. As we know according to the basic definition of the Nano particles that its size must vary between 1 nm to 100nm, also in general case their size can be between 1 nm to 1000nm. And in our hybrid composite we can conclude that the variation in the average size is near to specific dimension in nm as mentioned above.

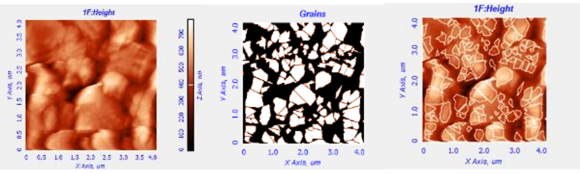

Fig -2: 1%CNT + BAMBOO+ EPOXY COMPOSITE

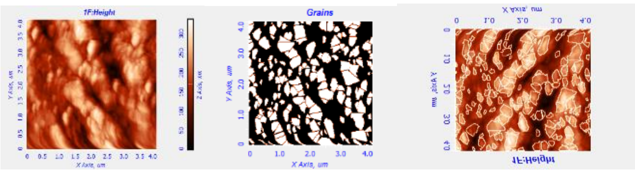

Fig -3: 2%CNT + BAMBOO+ EPOXY COMPOSITE

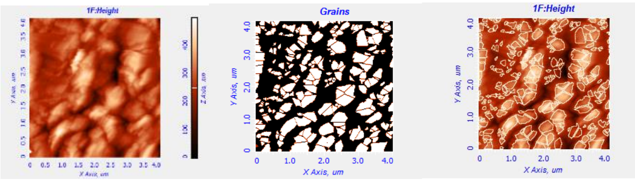

Fig -4: 3%CNT + BAMBOO+ EPOXY COMPOSITE

As explained earlier, that to be the particle in the Nano range i.e. nanoparticles should be in the range between 1nm to 100nm specific & 1nm to 1000nm in general, so we got the results for 1%, 2% & 3% CNT+Bamboo+Epoxy samples around in between these range i.e. 210 mm, 177mm, 154mm average size. Also, the no. of grains in the samples of variation 1%, 2%, 3% CNT+Bamboo+Epoxy were 137, 181 and 229 consequently. This shows that amount of grains increased as increase in the percentage of CNT in the hybrid composite.

3. CONCLUSION AND FUTURE SCOPE

Proper scattering of Nano particles in the epoxy resin is done by sonification process just after stirring at suitable rpm. Also, the use of coupling agent i.e. acetone improves interaction between the nanoparticles and matrix hence giving a strong interface region. In varying weight percentage loadings there is a proper dispersion of Nano particles but on increasing the weight percentage of reinforcement above 10% good results should obtained. There was an increase in the tensile, impact and flexural properties from 1 % to 3 % of CNT loading in both polymer matrix composite and also 1-layer bamboo fiber reinforced hybrid composite. These increment shows that; the interface of the major Bamboo fiber mat plays a vital role in the property of the hybrid composite material. Results also shows that further increasing the percentage of CNT nanoparticles in the composite will enhance the properties of the composite to a major extent.

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