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Investigation of Properties and Dynamics Mechanical Analysis of Glass fiber / Human hair / Coir fiber reinforced epoxy polymer Hybrid Composites

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ABSTRACT

This paper presents the study of the mechanical and water absorption characteristics of the Glass fiber / Human hair / Coir fiber reinforced epoxy polymer composites. G-H-C-G, C-H-G-C, and H-C-G-H reinforced epoxy resin matrix composites have been developed by hand lay-up technique with varying process parameters such as fiber condition. Tensile strength various from 42 Mpa to 56 Mpa, Tensile modulus varies from 48 GPa to 52 GPa, flexural strength varies from 46 MPa to 52 MPa, flexural modulus varies from 42 Gpa to 50 Gpa, shear study and fracture study was carried out. Effects of central open hole on the tensile strengths of the composites were studied by five sets of tensile specimens containing central open holes of five different diameters. Dynamic mechanical analyzer (DMA) was used to examine the dynamic mechanical properties of composite laminates with increasing temperature. The optimum mechanical properties were obtained in the treated fiber composite. Results showed that the composite sample, which has human fabric at the outer layers, has the highest storage and loss modulus. Besides, it was observed that glass transition temperature (Tg) of samples are close to each other and at about 75 °C. The fracture surface of the composite shows that pull out and de bonding of fiber is occurred.

Keywords: Glass fiber / Human hair / Coir fiber fiber hybrid, mechanical, open hole, DMA, SEM.

INTRODUCTION:

Natural fibers are derived from plants, animals and mineral sources. In modern days, the natural fibers from plants like sisal, banana and jute mixed with the glass fiber are used to get high strength (HS) hybrid composite materials which are widely used in many applications. High strength composite materials are replacing the metallic materials when used in the aerospace, structural and automobile industries.

Hybrid laminates exhibited superior dynamic mechanical performance, even compared to the pure glass laminate. Lower tan delta peak height (related to better fiber-matrix interaction) values and higher Tg were reported for the [C/G/ G¯]s and [G/C/ C¯]s samples which, together with the [G/C/ G¯]s sample, exhibited the best results for reinforcement effectiveness and loss modulus peak height [1]. Polyester based hybrid composites are prepared by Hand lay-up technique followed by static compression having constant 25 wt.% of fibre content with various stacking sequences. A significant improvement in flexural properties of sisal fibre reinforced polyester composite is observed by incorporation of glass fibre [2]. Studied an effect of various curaua (C) /glass (G) interlaminar hybrid composites were hot compress molded with an overall fiber loading of 30 vol.% and a volume ratio of 1:1 with the aim of studying the influence of the fiber stacking sequence on their thermal, mechanical, and dynamic mechanical properties. Higher hardness was observed when glass fiber was near the surface being tested and the presence of two consecutive glass layers yielded competitive impact properties in comparison with pure glass composite [3]. Mechanical tests indicated an increase in tensile, flexural, and impact strength of the BGRP hybrid composites at a bamboo: glass fiber ratio of 15:15 ratio in the presence of 2wt % of MAPP. Nearly, 69, 86, and 83% increase in tensile flexural and impact strength respectively has been observed as compared with virgin PP [4].

In this research work two hybrid composites have been developed using Glass, Jute, Sisal and Banana fibers in the form of laminates, namely Jute-Sisal- Glass (JSG) and Jute- Banana-Glass (JBG) combinations. The fabricated test samples have been subjected to tensile, flexural and impact tests to evaluate their mechanical properties. The microstructures of the tested specimens have been performed through SEM for fracture mode analysis [5]. In the present investigation, the effect of hybridization on mechanical properties on Kenaf and Banana Reinforced Polyester composite (KBRP) were evaluated experimentally. The results demonstrate that hybridization play an important role for improving the mechanical properties of composites. The tensile and flexural properties of hybrid composites are markedly improved as compare to unhybrid composites [6]. The present work emphasis the sisal/cotton fiber woven mat reinforced polyester composites preparation and analysing the tensile behaviour (Dry and wet condition) by varying the fiber volume fraction (10, 20, 30 and 40%).At dry condition, while increasing the fiber content increases the tensile strength and modulus of the composites up to the volume fraction of 30%.Further increase in fiber volume fraction decreases the tensile strength and modulus. Water absorption was carried out for 24 hours with different condition. This reduces the tensile properties [7]. The experimental investigation reveals that the properties of composite increases with the incorporation of Al2O3 particulates. It is observed that the density of composites increases with increase in fiber content, while a decrease in density is observed with increase in fiber length. The strength properties of the composites increases with the increase in fiber content up to 15 wt.% and 12mm fiber length, however further increase in fiber length and fiber content the value decreases [8]. Water absorption studies were performed for four different soaking times of 100, 250, 500, and 1000 h at room temperature. To clearly understand how long this type of composites can endure without any important loss of mechanical properties, tensile and impact tests were performed after 500 and 1000 h of water immersion time [9].

The perforation impact energy, peak load and energy absorbed of the composites increased when the bamboo content was increased. The perforation impact energy was at 55 J for the BPP50% composite, compared to that of neat PP at 20 J [10]. Dynamic mechanical analyzer (DMA) was used to examine the dynamic mechanical properties of composite laminates with increasing temperature. Results showed that the composite sample, which has carbon fabric at the outer layers, has the highest storage and loss modulus. Besides, it was observed that glass transition temperature (Tg) of samples are close to each other and at about 75 °C [11]. Study the mechanical behavior of hybrid composites based on jute and oil palm fiber. It has been found that the use of hybrid system was effective in increasing the tensile and dynamic mechanical properties of the oil palm-epoxy composite because of enhanced fiber/matrix interface bonding [12].

Experimental investigation on the depicts that addition of quite small amount of glass fiber to the pineapple leaf fiber and sisal fiber-reinforced polyester matrix improves the mechanical properties of the resulting composites. The study also reported that the water absorption tendency of composites decreased because of hybridization and treatment of bio fibers [13]. Dynamic Mechanical analysis of FRP composites based on different fibre reinforcements and epoxy resin as the matrix material [14]. Investigated the influence of laminate thickness, stacking sequence, and thermal aging on the damping behavior of carbon/epoxy laminates; the authors concluded that a mechanism of damping within composite structures mainly depended on the stacking sequence [15]. Accordingly extensive studies have been carried out to make use of natural fibres and in preparation of polymer matrix composite replacing the synthetic fibre with natural fibre like jute, sisal, pineapple, bamboo, kenaf and bagasse and the mechanical properties of natural-glass fibre reinforced polymer composites [16].

The mechanical properties of woven banana fibre, kenaf fibre and banana/ kenaf hybrid fibre composites were studied and found that, it increases due to hybridization of kenaf with banana fibres. Tensile, flexural and impact strengths of the woven hybrid composite of banana/kenaf fibres are superior to those of the individual fibres [17]. Mechanical properties of hybrid glass fibre-sisal/jute reinforced epoxy composites were evaluated and it was observed that the incorporation of sisal fibre with Glass Fibre Reinforced Polymers (GFRP) exhibited superior performance rather than the jute fibre reinforced GFRP composites for tensile properties and in contrast, jute fibre reinforced GFRP composites performed better in flexural properties [18]. The effect of number of carbon layer on the natural frequency and mode shape for hybrid fiber (carbon/glass) with epoxy composite laminates were investigated. The natural frequencies increased when the number of carbon/epoxy layers [19]. Study the mechanical properties of short sisal fibre reinforced polypropylene composites. The influence of fibre length, fibre loading and fibre orientation on the mechanical properties of composites has been evaluated. Fibre length of 2mm was found to be optimum for the best balance of properties in the case of melt mixed composites [20].

Effects of HHC loading on CPCs and CCs are evaluated through static and dynamic mechanical thermal analysis, density, electrical conductivity, morphology, and microstructure studies. Tensile and flexural properties (strength and modulus) of CPCs and CCs improve significantly (~25 to 73%) at 30 wt% HHC loading. Storage modulus (E′) and loss modulus (E″) of CPCs increase up to 132 and 104%, respectively with addition of HHC up to 40 wt%. E′ and E″ of unfilled CCs increase with carbonization temperature, however they decrease with increasing HHC content [21]. Investigation on sisal natural fiber composites with and without silica by incorporating 100% biodegradable sisal fibers as reinforcement in the polyester matrix. The results showed that the tensile strength and tensile modulus of composites with silica are 1.5 and 1.08 times greater than that of composite without silica respectively. The impact strength of composite with sand 1.36 and 1.8 times greater than that of composites without silica and plain polyester, respectively [22].

The drilling experiments were performed according to the full factorial design. Analysis of variance (ANOVA) was used to determine the impact of layering arrangement of fibers, feed (0.06, 0.18, 0.3 mm/rev), speed (1000, 3000, 5000 rpm), tool geometry (Plexi Point, Brad, Parabolic) and their interactions on TF and delamination [23]. The short coir–fibre-reinforced composites exhibited the tensile, flexural and impact strength of 16·1709 MPa, 29·2611 MPa and 46·1740 J/m, respectively.

The regression equations were developed and optimized for studying drilling characteristics of coir–polyester composites using the Taguchi approach. A drill bit diameter of 6 mm, spindle speed of 600 rpm and feed rate of 0·3 mm/rev gave the minimum value of thrust force, torque and tool wear in drilling analysis [24].

Study the mechanical properties of hair and coir reinforced with epoxy resin. Tensile, Flexural and Impact tests were conducted on specimens with different combinations of hair and coir in epoxy resin. Results indicate that the tensile strength of the composite increased due to hair reinforcement [25]. The properties of manufactured composite were evaluated experimentally using computerized UTM machine according to ASTM standards. The results revealed that the tensile properties were increased with the increase of composite thickness. The values of tensile strength and Young's modulus of pineapple fabric composite were exhibited higher than the jute composite and the quite opposite trend were observed in case of elongation and water absorption percentage [26]. Largely centered on wigs, hair extensions, and so forth, this trade also has been a source of many of the above mentioned environmental and health problems. Due to hair dust and decaying hair, workers of many hair-processing units in India have increased cases of tuberculosis and respiratory tract infections [27, 28].

Nadendla Srinivasababu et al., investigated the untreated and chemically treated fibre is reinforced into the polyester matrix and the composites are fabricated to test their mechanical and dielectric properties. The high tensile strength of 82.39 MPa, modulus of 1.05 GPa is obtained for broom grass CT – 1, CT – 2 fibres respectively [29]. Tharaknath et al., effect on the fabrication of polymer matrix composites by using natural fibres like coir, and luffa which is in abundant nature in desired shapes by the help of various structures of patterns and calculating its material characteristics by conducting tests like tensile test, flexural test, hardness test, water absorption test, impact test, density test, SEM analysis [30]. Thiruchitrambalam et al., effect of alkali and SLS (Sodium Lauryl Sulphate) treatment on Banana/Kenaf Hybrid composites and woven hybrid composites. The fibers are treated with 10% of sodium hydroxide (NaOH) and 10% Sodium Lauryl Sulfate (SLS) for 30 minutes. The fiber content in the composite is kept constant at 40 %. The variation in the Mechanical properties and morphological changes are studied [31]. Verma et al., effect of mechanical properties of layered bamboo–epoxy composite laminates including tensile strength, compressive strength, flexural strength and screw holding capability have been evaluated [32]. Panneerdhass et al., Effects of volume fraction on the Tensile, Compressive, Flexural, Impact strength were studied. SEM analysis on the composite materials was performed. Tensile strength varies from 10.35 MPa to 19.31 MPa, compressive strength varies from 26.66 MPa to 52.22 MPa, flexural strength varies from 35.75 MPa to 58.95 MPa and impact energy varies from 0.6 Joules to 1.3 Joules, as a function of fiber volume fraction [34]. Raju et al., prepared the composite with different weight % of randomly distributed ground nut shell in polymer matrix. The addition of the ground nut shell to the polymer composite results reduced thermal conductivity and increases the glass transition temperature of the composites [35].

The scarcity of literature on morphologically different natural reinforced composites directs us towards the development of glass fiber/coir fiber/ human hair hybrid composite. In this work, epoxy based polymer composites were prepared with glass fiber with human hair as the reinforcing materials. The tensile, compressive, impact and flexural tests for glass fiber/coir fiber/ human hair reinforced epoxy composite, its efficiency in terms of energy and time, and mechanical characteristics in comparison with those of strength and modulus composite and SEM analysis of fractured surfaces of the composite were performed.

EXPERIMENTAL PROCEDURE:

Polymer Matrix and Fibers

The matrixes used for the preparation of hybrid composite are Epoxy resin (LY56 & hardener HY 951) purchased from Javanthi Enterprises – Guindy. The raw material of Glass fiber purchased from sakthi fiber saidpet Chennai, India and the natural fibers coir were purchased from Ever Green fiber, CMBT –Chennai, India.

Coconut coir fiber, or in world trade is known as Coco Fiber, Coir fiber is a byproduct of coconut coir processing. Traditionally coconut coir fiber is only used for brooms, mats, ropes and tools of other household. Technological developments, physico-chemical properties of fibers, and consumer awareness to return to natural materials, made of coconut coir fiber utilized as industrial raw materials carpet, upholstery and dashboard of the vehicle, mattresses & pillows. Coir fiber samples collected from pollachi.

Human hairs are used to make the composite material because human hairs are easily available in any beauty parlour. Human hair samples collected from local beauty parlour from tindivanam, which are black in color and six centimeters in length. Collected hair sample are clean and washed three to four time to remove the oil and impurity present on the surface of hair. To remove the moisture content from hair process of blow drying is done.

The hybrid composite material is made by four layers namely glass fiber, human hair and coconut coir fibers by various combinations as glass fiber-coconut coir-human hair-glass fiber (G-G), human hair –glass fiber –coconut coir –human hair (H-H), and coconut coir-glass fiber-human hair-coconut coir (C-C). The laminations of hybrid composite mat were built in the form of Bidirectional and it has an orientation like wrap (90^0) and weft (0^0).

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a) Glass fiber **b) Coconut Coir** **c) Human Hair**

Figure-1 Reinforcing Fiber Mats

Types of Composite and fiber	Glass	Coir	Human Hair
G-G (glass-human hair- coir -glass)	15%	10%	10%
C-C (coir-human hair-glass-coir)	10%	15%	10%
H-H (human hair-glass-coir-human hair)	10%	10%	15%

Table:1. Weight percentage of matrix, fiber

Fiber Chemical Treatment:

To modify the surface condition of coconut coir the chemical treatment were executed. The natural reinforcements coconut coir was soaked in a 5% NaOH diluted solution for the three hours duration and naturally dried at room temperature. By using the deionised water the treated fibers were washed to remove excess alkaline residue [3].

Fabrication of composite laminates:

Epoxy resin (LY556 & hardener HY951) and fibers are the raw materials used for the fabrication of composites. The volume of fiber should not exceed 35%. These fibers were stacked in sequential manner by placing one another in hybrid composite material as shown in Figure A, B, and C. The specimen is prepared by using a hand-lay method. Moulds can be made of wood, plastics, composites or metal depending on the number of parts, cure temperature, pressure, etc., here the wooden mould of 300*300*3 mm 3 was used and for the ease removal of laminates from the mould the inner side was coated with mansion wax. Polymer mixer 1.5% accelerator, promoter and catalyst are mixed with epoxy resin. As per the stacking sequence Glass - Coconut coir - Human hair - glass hybrid composite (G-G), Coconut coir - Glass - human hair - Coconut coir hybrid composite (C-C), and Human hair - glass - coconut hair - human hair hybrid composite (H-H) , are coated with the polymer mixer and prepared by using the hand layup method. The composite is completely cured under the ambient conditions and with the aid of external load for minimum duration of 24 hours duration. The test samples were cut to the required sizes prescribed in the ASTM standards and weight fraction is shown in table -1.

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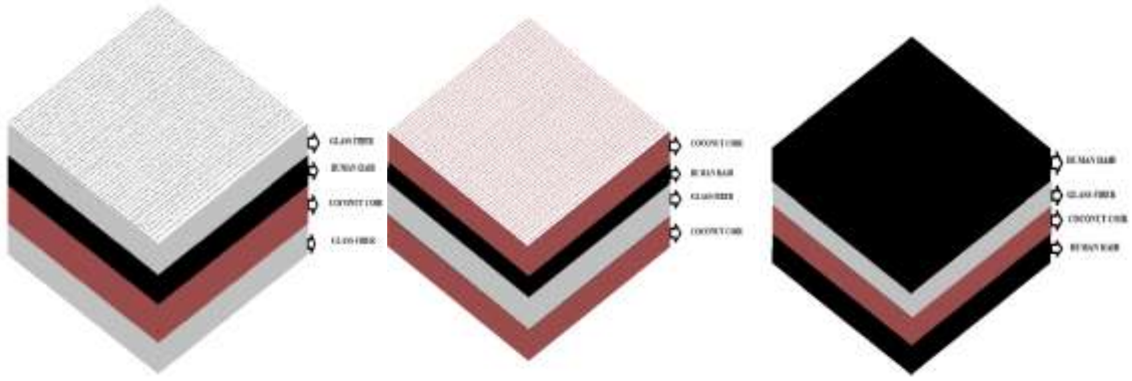

Figure -2 Fiber Mat stacking sequence a) G-G (glass-human hair- coir -glass**) b) C-C (**coir-human hair-glass-coir**) c) H-H (**human hair-glass-coir-human hair**)**

Water absorption:

The water absorption tests of composites were carried out following ISO 527. To measure water uptake capacity of composite, the specimens were prepared and distilled water was the medium. From the difference of final and initial weights before and after immersion in water bath for 24 h, percentage of water uptake was calculated. In each test and type of composite, 5 specimens were tested and the average values were reported. The testing was carried out until the percentage of water uptake reach equilibrium. The calculation was based on equation 1 [9].

$$M_t\% = \{w_t - w_o\} / w_o \times 100 \quad \text{------------ (1)}$$

Tensile and Open hole tensile testing:

The test samples are prepared according to ASTM D638 for tensile and open hole tensile test for are carried out in computerized UTM at the speed of 5mm/min, and different size of hole performed in the composite from 3-10 mm with a step of 1mm dia. HSS drill was used with a point angle of 118°. The drilling operation was carried out in a radial drilling machine without ancillary plate at the bottom of composite sample. The round hole specimens were prepared as shown in figure -1, a, b and c. Universal testing machine (Instron 3369) used to determine a tensile strength of the specimens of length 165 mm and width of 19 mm. A cross head speed 5mm/min was maintained throughout the experiment. In each case eight samples were tested and the average values are reported. The tensile test was carried out on the open hole G-G, H-H, C-C composite are shown in figure.-1. There will be variation in tensile strength, according to the open hole diameter on the H-H composite. Sample with 3mm diameter i.e., the open hole (notched) tensile values are nearly equal to the un notched tensile strengths, which are 8.86 Mpa to 15.8 Mpa [23]. A probable reason for this trend coated to the fact that increase in hole diameter cause reduction in the cross sectional area in the proximity of the hole which promotes early failure.

Flexural test:

The test samples are prepared according to ASTM D790 for three point bending test. The flexural tests are carried out in computerized UTM at the speed of 2 mm/min. Ten rectangular specimens of each fibre content were cut from the manufactured composite laminates. Five specimens

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(90 mm × 15 mm × 3 mm) were tested for each case, dry or wet samples; the average values for flexural strength, strain, and modulus were reported as a result [16].

Shear study:

Three specimens were test is conducted in universal testing machine. The specimen as per ASTM D 7617M-11 (length of 225 mm, with 5mm centre gap, support on either side) is fabricated for a suitable cross-section and fixed in a fixture and the double shear force is applied till the three samples are completely sheared. The load Vs deflection curve is generated and the peak load indicates the shear strength [17].

Fractrography study:

Morphological studies were carried out using SEM to investigate the dispersion of fiber material in the polymer matrix. It was performed in Hitachi S3400N scanning electron microscope. Composite samples were sputter-coated with gold to avoid charging. The SEM micrographs were obtained under conventional secondary electron imaging conditions with an acceleration voltage of 10 kV [17-18].

DMA Analysis:

The hybrid composite of influence of temperature and frequency on the modulus and damping property was evaluated using Dynamic Mechanical Analyzer SEIKODMAI - DMSC 6100 according to ASTM D7028 Standard. The three specimen (G-G, H-H, C-C) of dimension 40x13x3mm^3 was used under tensile mode of temperature range between 30^{0}C to 180^{0}C at a heating rate in a 5^0 C/min the tests were carried out by frequencies of 10 Hz [1-2,14].

RESULTS AND DISCUSSION

Water absorption

The water absorption test was carried out as described by ASTM D 570 specimen with dimension 50x25x3mm were labeled as G-G, C-C, H-H and EPOXY hybrid bio composite sample and immature in distilled water [7]. Then the sample were collected every 10days and dried to a constant weight at thermal room temperature the preset moisture constant/weight gain is calculated by following equation

$$m_i = \frac{W_i - W_b}{W_b} 100 \quad \text{---------------------- (1)}$$

Where,

m_i- Percent weight gain (g)
W_i-weight at the specimen time (t)
W_i-base line mass (oven dry specimen mass) (g)

show the behavior of moisture up-take of the G-G, C-C, H-H and Epoxy hybrid matrix composite samples Initially all sample Glass - Coconut coir - Human hair - glass hybrid composite (G-G) 7.5% - 10% - 10% - 7.5%, Coconut coir - Glass - human hair - Coconut coir hybrid composite (C-C) 7.5% - 10% - 10% - 7.5%, and Human hair - glass - coconut hair - human hair hybrid composite (H-H) 7.5% - 10% - 10% - 7.5% had, sharp linear increase in moisture absorption and reached their saturator state

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with maximum moisture content absorb in this materials all the composition before weight 6g and after 50Hrs to 550Hrs, shown the result in all composition result in fig:3 [8-9].

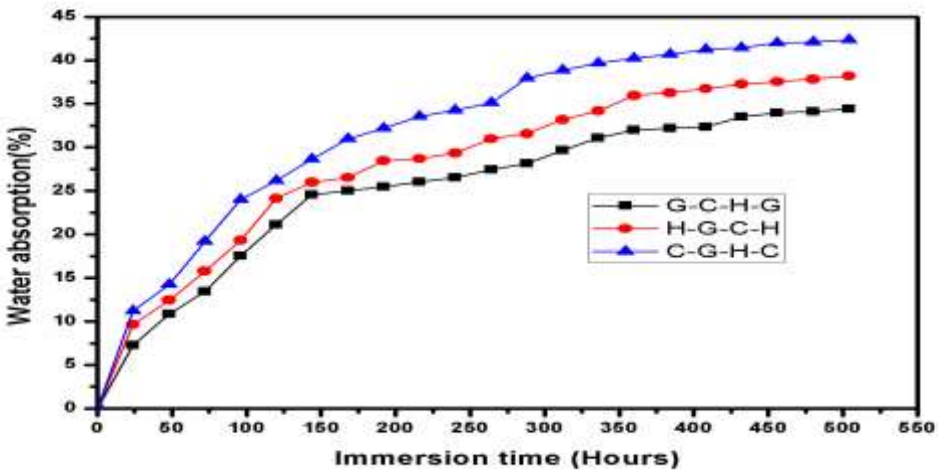

Fig:3. Water absorption

Tensile and open hole tensile strength

Fig:4 Specimens of tensile strength

Fig:5 Specimens of open hole tensile strength before drill

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Fig:6 Specimens of open hole tensile strength after drill

The tensile strength of reinforced epoxy resin is found to be 31.68 Mpa, the variation of tensile strength and modulus for various laminate stacking sequence is shown in figure -1, a, b and c respectively. The tensile strength and modulus of the composite is influenced of the fiber. The tensile strength and modules of laminated C-C when only 2-layer coir and single layer glass and human hair one reinforced matrix is found to be 31.68 MPa greater than the tensile strength and modules of the resin respectively [8].

It is found that there is sharp in cruss in tensile strength which the incorporation of H-H and G-G of glass fiber as extreme glass plies and human hair composition H-H, G-G the increase tensile strength and modules of hybrid composite is attributed to the reason that glass fiber and HH stronger and stiffer that C-C increased in the tensile strength and modules of increased for H-H and G-G reinforced hybrid composite laminate. When compared to that only C-C laminate, Fig: 3 revels that the tensile prepares are slightly affected by layering sequences observation of failed specimens reviewed that failure in C-C laminate is sudden with no or little pull out of C-C composition when as in hybrid laminates, failure is governed by extensive fiber pull out and breakage [9].

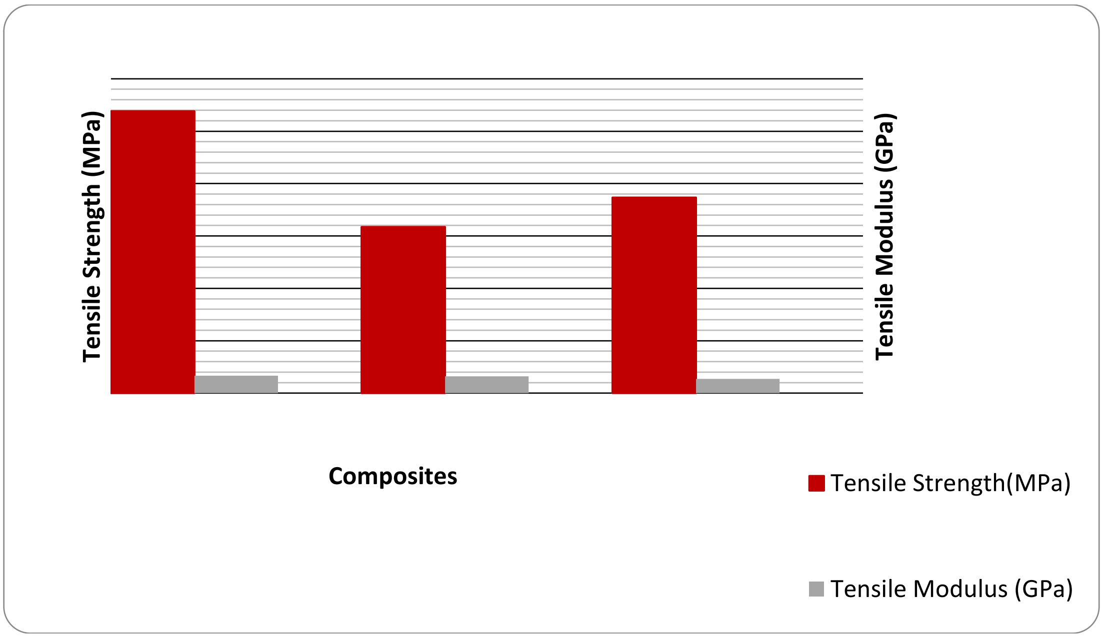

Fig: 7 Comparisons of Tensile Strength and Tensile Modulus

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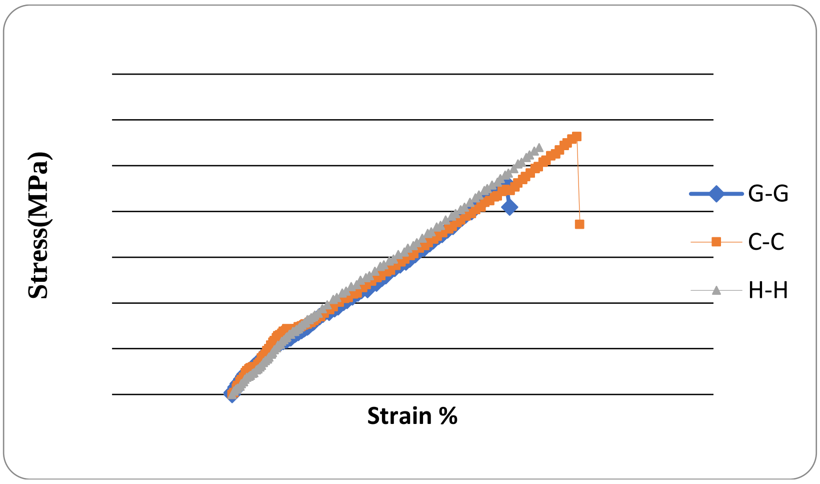

Fig: 8 Comparisons of Stress Strain Curves

Composite drilled with different size of hole from 3-10 mm with a step of 1 mm dia. HSS drill with point angle 118° was used. The drilling operation was carried out in a radial drilling machine without ancillary plate at the bottom of composite sample. The open hole specimens were prepared as shown in "Figure.5.and 6." Typical open hole drilling before and after specimens results for tensile strength and tensile modulus as shown in Figure.9 and 10 [5-6].

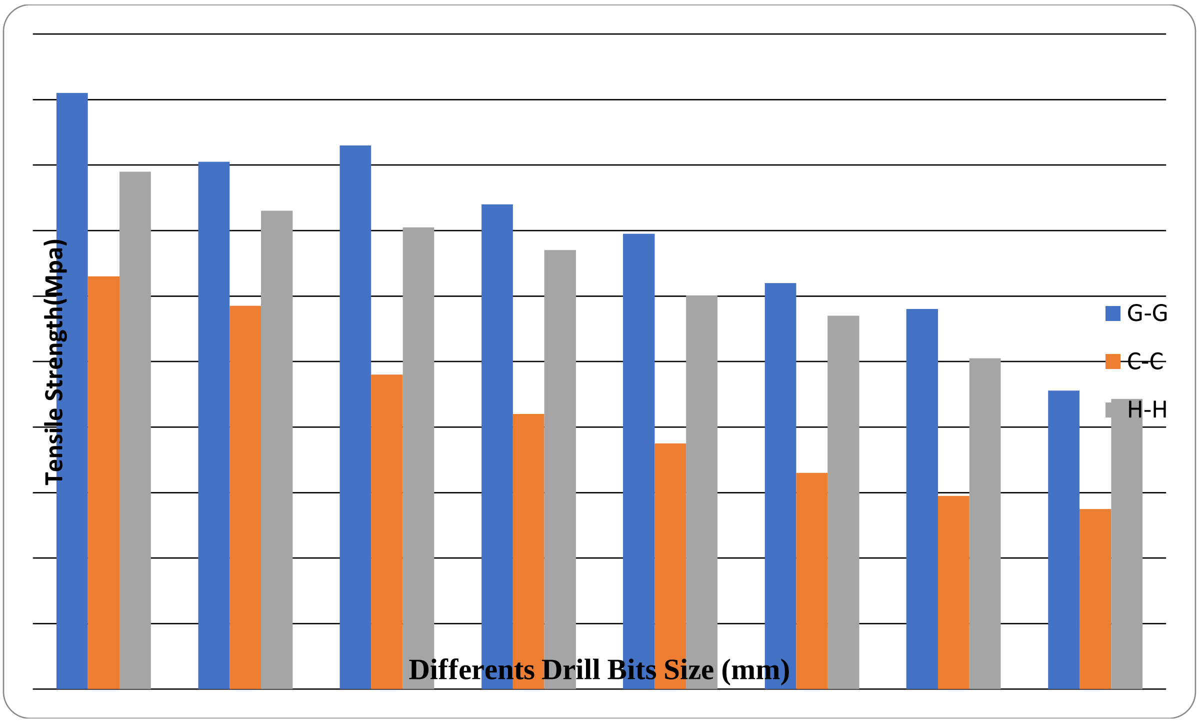

Fig:9 Open Hole Tensile Strength

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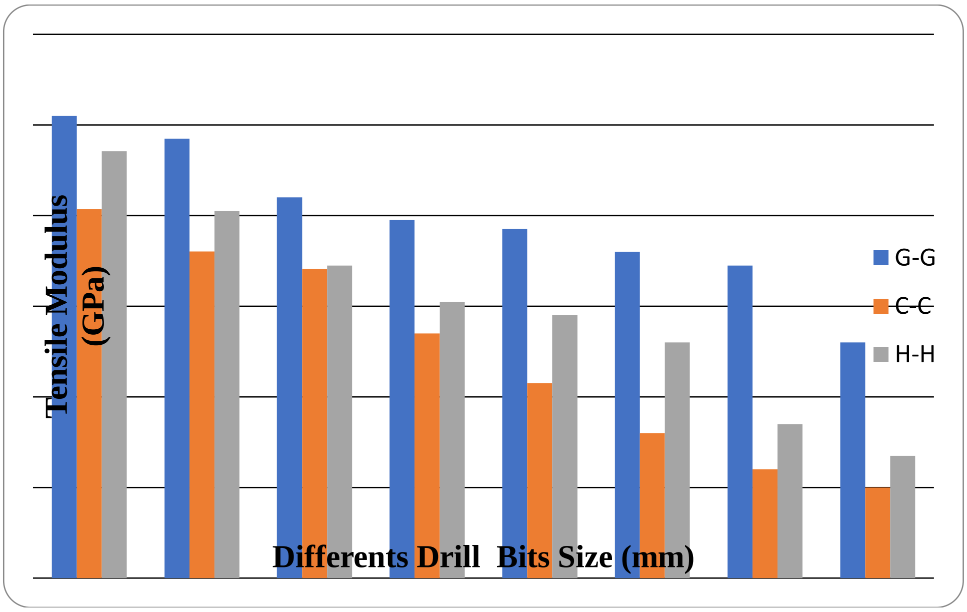

Fig:10 Open Hole Tensile Modulus

Flexural Test

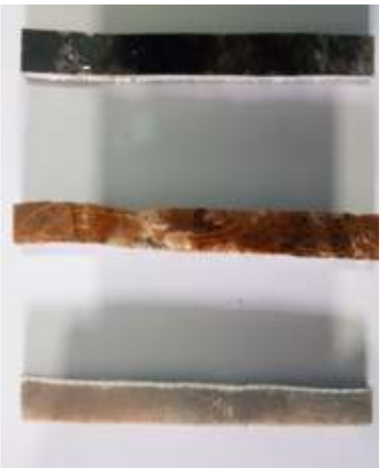

Fig:11. Flexural Test

The load deflection diagram for various hybrid composite stacking sequence are show in Fig:11. All the curves indicate non-linear behavior. The point of deviation from linearly is failure indication due to development of crack on the tension side ,flexural strength and modulus for laminates with different stacking sequence are compared in Fig:12 and 13 respectively, flexural properties is increased G-G and H-H laminated is higher flexural properties compared to C-C this revels that plies at the extreme and G-G fiber plies at the middle loads to considerable improvement in flexural strength this can be justified from the fact, the flexural strength and stiffness are controlled by extreme layers of reinforcement flexural strength and modulus that the strength and modulus of an reinforced samples respectively . The laminated G-G found to have highest flexural strength of 39.9 MPa and 44.0 MPa respectively higher than strength and modulus of all other H-H and C-C laminate

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respectively, by alters the sequence of arrangements as in the layer of H-H and C-C no improvement in the flexural properties compared to G-G this laminated can achieved [13].

The sequence G-G and C-C lowest flexural strength 49.2mpa and 4500mpa, 37.2 mpa and 5500mpa among all hybrid composion the evident from SEM. Greater extensibility of glass fiber leading to large fiber pull out and matrix failure could be observed from the Fig:11. No de lamination factor G-G plies is noticed for flexural specimens

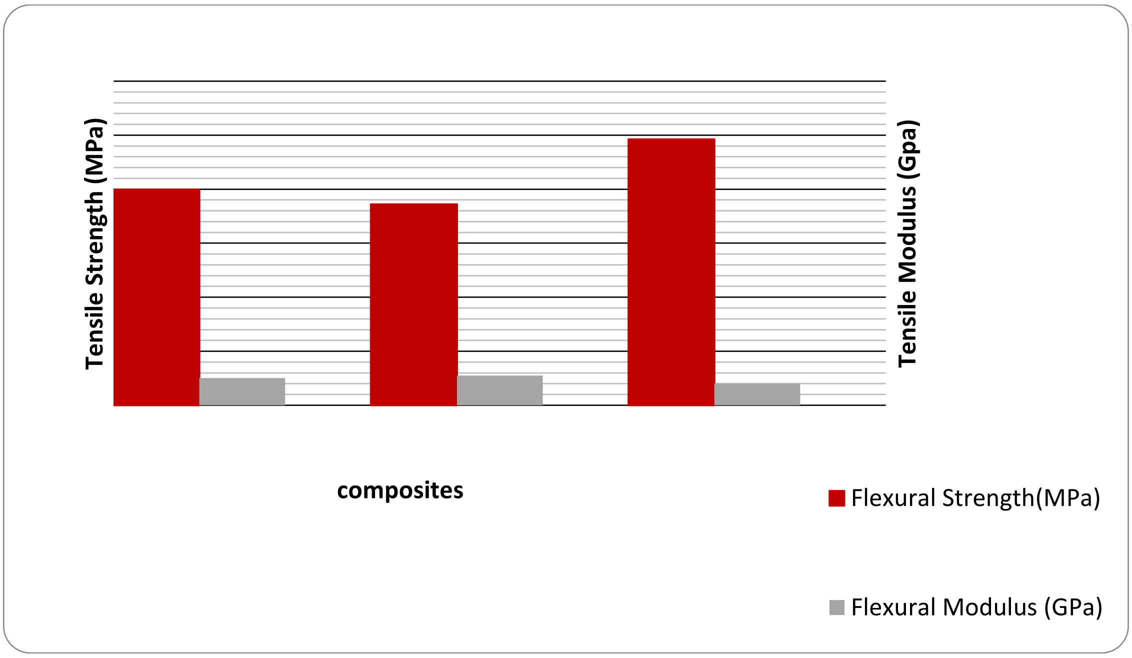

Fig:12. Comparisons of Flexural Strength and Flexural Modulus

Shear study:

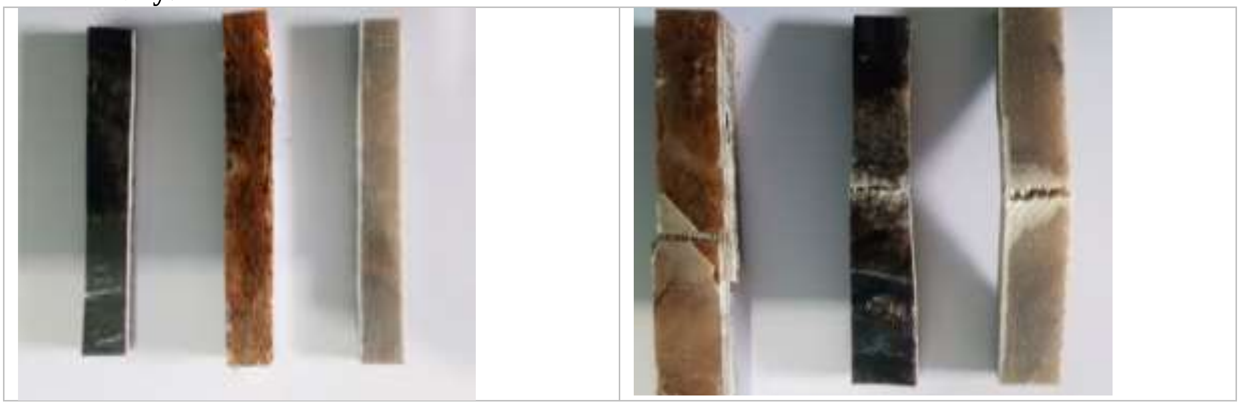

Fig:14. Shear study

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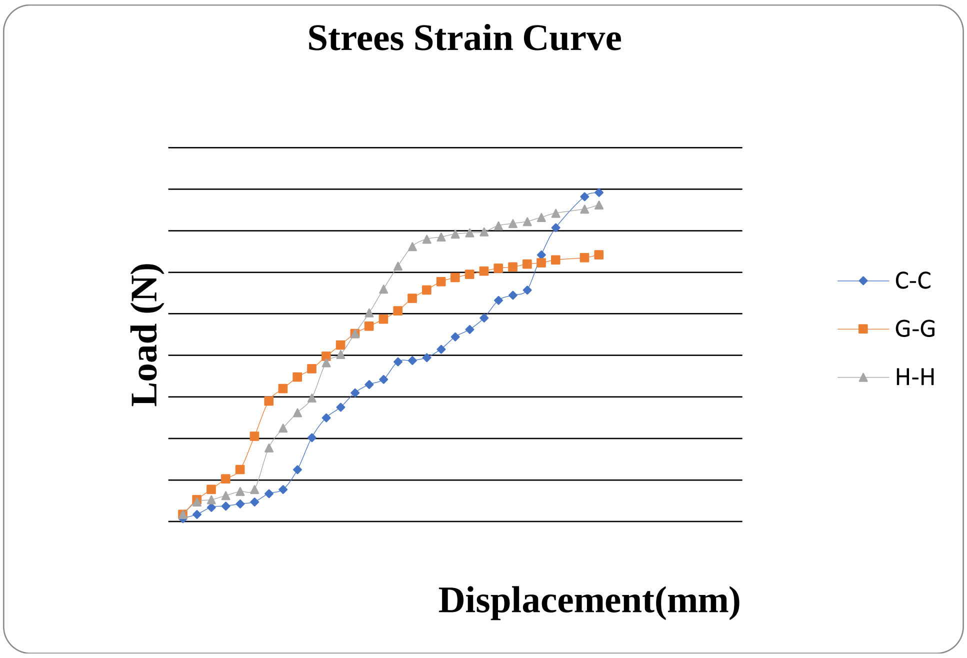

Fig: 13. Comparisons of Stress Strain Curves

The increase in shear strength of the coir fiber composite does indicate that there is greater wetability between the coir fibers and the modified epoxy matrix. The flexural strength of the modified epoxy matrix and coir composite is as depicted in Fig.13 [16].

Fracture study

The effect of the surface treatment on the interface between the human hair, glass fiber and coir fiber was studied by referring to the fractured surface of the tensile test specimens (Fig. 14). For treated composition, it shows there were gaps between the fiber and the matrix, indicating poor adhesion. The gaps were less apparent for composites whose human hair, coir, glass fiber was silane treated. The narrower gaps between human hair, glass fiber and coir fiber for alkine treated composites evidenced better compatibility. This was reflected by the higher mechanical properties to some extent.

The SEM micrographs of the fractured surface of the coir composites (Fig. 14) show the crack propagation occurring in the modified epoxy matrix around the coir fibers. The presence of embedded coir fibers stimulates shear deformation because points of maximum stress concentration develop around the equators of such particles when the resin is stressed. The resulting plastic deformation helps to blunt a propagating crack tip and suppress fracture [16-17]. This mechanism coupled with fiber pull out has contributed to greater toughness of the composite.

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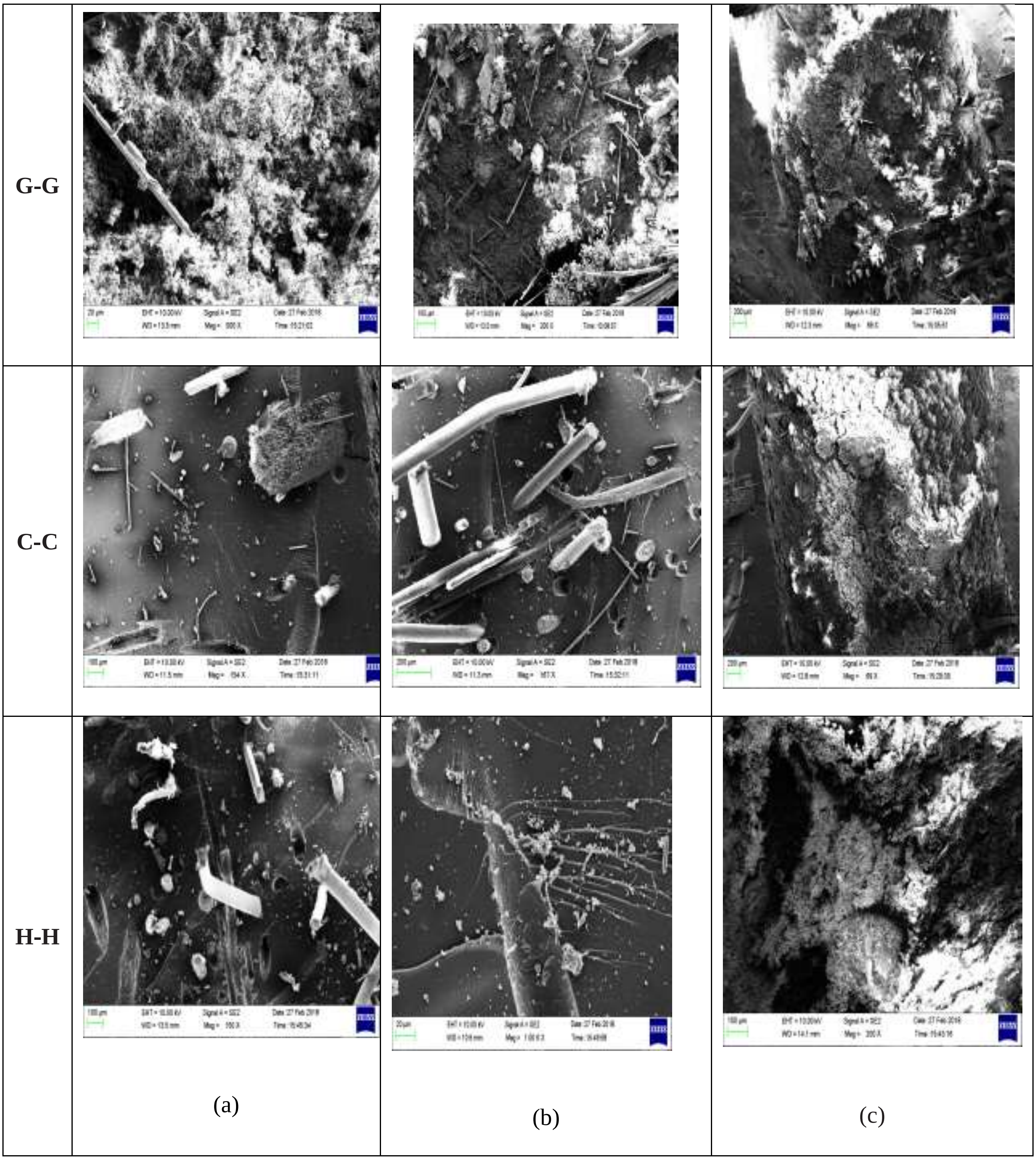

Fig:14. Fracture study

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Dynamic mechanical analysis

The effect temperature and frequencies on the storage of epoxy matrix and NaoH treated and un treated G-G, C-C and H-H fiber composition as studied are shown in fig.15, the testing temperature range from 25^{0}C to 200^{0}C and frequency in range of only high frequency 10 Hz . The figure shows that irrespective of frequency the energy absorbed by better at all temperature until 100^{0}C further. Increase in the testing temperature the energy absorbed by both the resin and the stacking sequence composite are high storage modulus because neat resin is low storage modulus absorbed this indicates that until 140^{0}C the fibers are transferring the load effectively Afterwards they tend to loosen their bonding with matrix failure in their function they are intended.

Researchers suggested fiber in the polymer matrix enhances the storage modulus or stiffness value of the composite. Another observation that the treated fiber increases the storage modulus value measured. This modulus rearrangement material causes the material reduction in localized stress at low temperatures, the molecules are so immobile that they are unable to resonate with the oscillatory loads and, therefore, remain stiff. The thermo set polymers have cross-link between every atoms is retained at all temperature and hence they are strong.

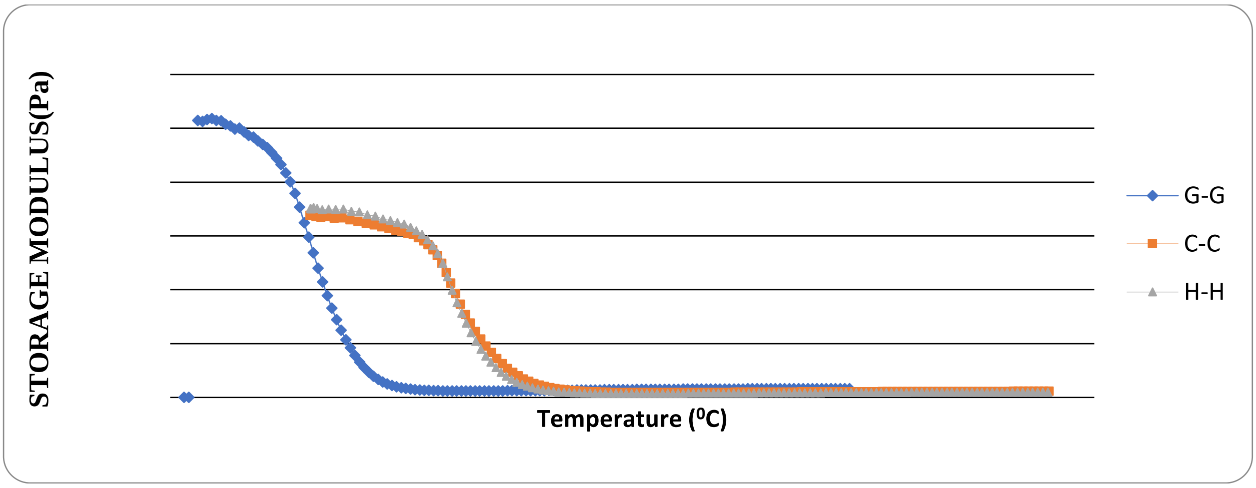

Fig: 15. (10 Hz) storage modulus Vs Temperature

The loss factor in general described as the ratio of loss modulus to storage modulus of the material this indicates the energy dispating of material during cyclic loading and shows the degree of molecular moment in the polymer chain show the plot of loss factor of stacking sequence of G-G this composition the indicates composite possesses better energy dissipation mechanism than matrix. At low temperature, the material is said to be in the glass state or energy elastic state [11-14].

A change of rubber-elastic state is glass transition. In this glass transition temperature is calculate using peak of tan delta valve. Irrespective of magnitude tan δ reduces when compared with epoxy resin whereas a clear shift in the glass transition temperature (Tg) is seen along. Synergetic effect between fibers forces the shift in Tg value. The peak of damping is associated with the glass transition region where the material changes from a rigid to plastic state. Initially, the molecules are stable, as with the rise in temperature the movement of small groups and chains of molecules within the polymer structure is set to begin. It shows the value of peak establishes the interaction between the homogenous and amorphous phase of the material. the decrease of small group and chain of molecules within polymer structure is set to begin then from higher the tan delta peak ,higher the degree of molecules mobility [12].

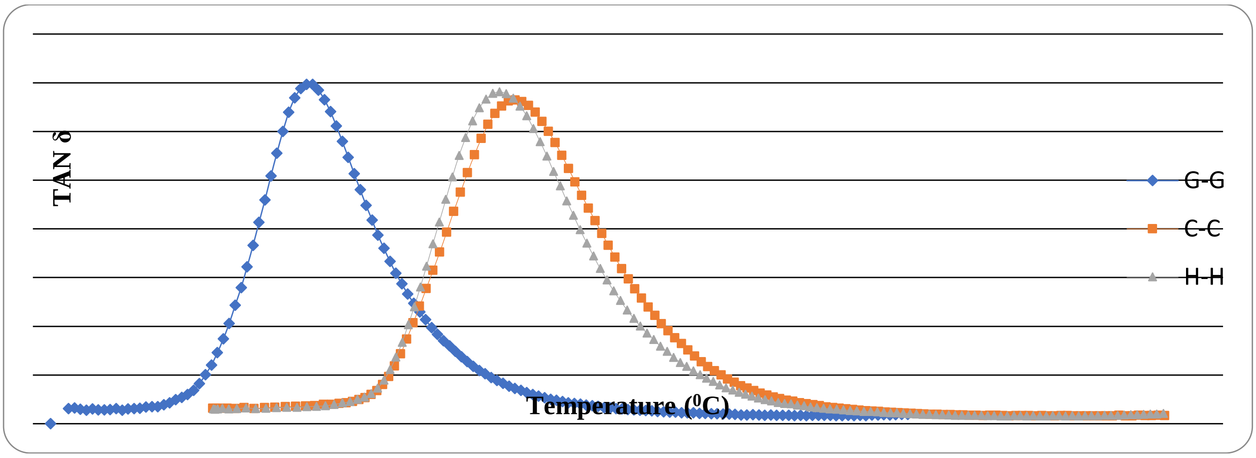

Fig: 16. (10 Hz) Tan Delta Vs Temperature

Loss modulus is viscous response of the materials. The variation of the loss modulus as a function of temperature is shown in Fig. 17. It was observed from Fig. 17 that loss modulus curves of G-C-H and C-H-G samples have had peak at about same temperature (50 °C), whereas H-G-C sample have had a peak at about 70 °C. Moreover, when the peak values were examined, it was seen that while highest loss modulus value of G-C-H is 2 GPa, it is 1 GPa and 0.4 GPa for C-H-G and H-G-C samples, respectively.

When loss modulus results are examined, it is observed that composite laminate sample which had glass fiber at the outer layers and coir fiber at the inner layers (CJJC) reached the highest loss modulus value among other samples. This can be due to the fact that, glass fiber at the outer layers resist the applied force and owing to this fact, loss modulus of this composite sample became higher [14].

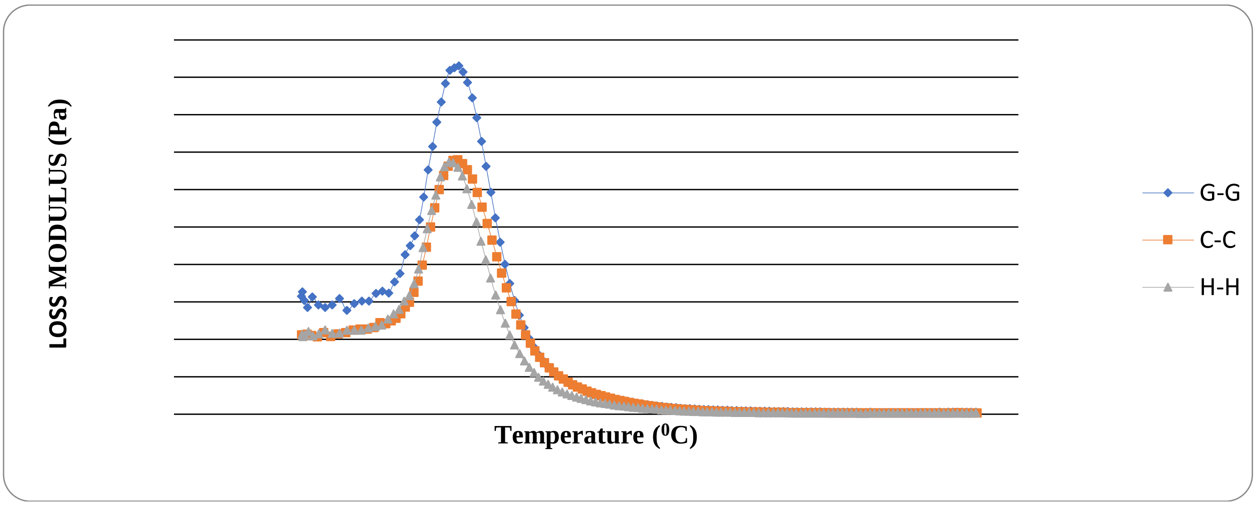

Fig:17. (10 Hz) loss modulus Vs Temperature

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CONCLUSION

In this work glass fibre, coconut coir, human hair reinforced hybrid composite fabricated and mechanical properties were evaluated. The observed mechanical properties like shear and fracture energy have given the opportunity to improve the composite fiber optimization and fabrication method. The hole sensitivity was found to increase with increasing hole diameter and a very negligible hole sensitivity was observed for a hole diameter of 3mm. It was observed that composites having human fiber content possess higher open hole tensile strength values than those with coir fiber content**.** The morphology of fractured surface observed by SEM suggests that the networking of structure restricts the pull out of fiber, which is responsible for higher mechanical properties for human hair fiber content.

DMA of three different glass/human/coir fabric reinforced composites were investigated and results showed that changing the position of fabric layers has a great effect on both storage and loss modulus of composite samples. By positioning high strength fabrics (human hair) to the outer layers resulted in high storage and loss modulus. Furthermore, it was observed that Tg value of samples were not affected from the positions of the fabric layers.

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