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FABRICATION AND MECHANICAL TESTING OF E GLASS MAT, KENAF MAT & FLAX MAT HYBRID COMPOSITE MATERIAL

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***Abstract*— In present scenario, natural fiber reinforced composites have raised more attention for the growth of biodegradable material and are somewhat replacing presently used artificial fibers. Natural fibers able to replace the synthetic fibers that it has the eminent benefits of like low density, small manufacturing cost, its availability, ease of manufacture, low development energy, non-abrasive, worthy acoustic property, biodegradability, reasonable mechanical strength, renewability. Composite was made-up by hand lay-up method with the bidirectional natural fibers and epoxy resin in a mould and cured under gradual pressure. In this research paper mechanical behavior such as tensile, impact, indentation capacity and water absorption test of E-Glass and kenaf/flax mat reinforced hybrid composite materials (GKFHC) studied. Composition of material was performed at 00 and 900 stacking sequences. The purpose of this work to investigate the mechanical characterization of the hybrid composite material. Sample was prepared and tested accordance to the ASTM standards. Validation of tensile strength operate with the help of ANSYS 17.1 software.**

***Index Terms*— Composite Material, E Glass Mat, Kenaf Mat, Flax Mat, Mechanical Testing.**

I. INTRODUCTION

A. COMPOSITE MATERIAL

Composite fiber (Kevlar, carbon) have high cost which is inexpensive fiber. Such materials are used which are less expensive, specific strength, biodegradable is known as natural fiber. These do not have high strength as of synthetic fiber by Chandramohan and D & .K. Marimuthu and K (2011). In packaging, inner parts of automobile polymer composite are used at the wide level. Polymers formation is obtained by the vacuum forming, extrusion and various different methods. These compounds sustained the durability, specific properties like toughness, resistance etc. The definition of the composite given by the lartiz is "composite is multifunctional material which provides the discrete characteristics, cohesive structure with different material combination". It is having wider significance due to distinguishing property. Composite are the combination of the compound material but it is different from the alloys due to attribution of its advantage not its shortcoming.

B. CLASSIFICATION OF COMPOSITE MATERIAL

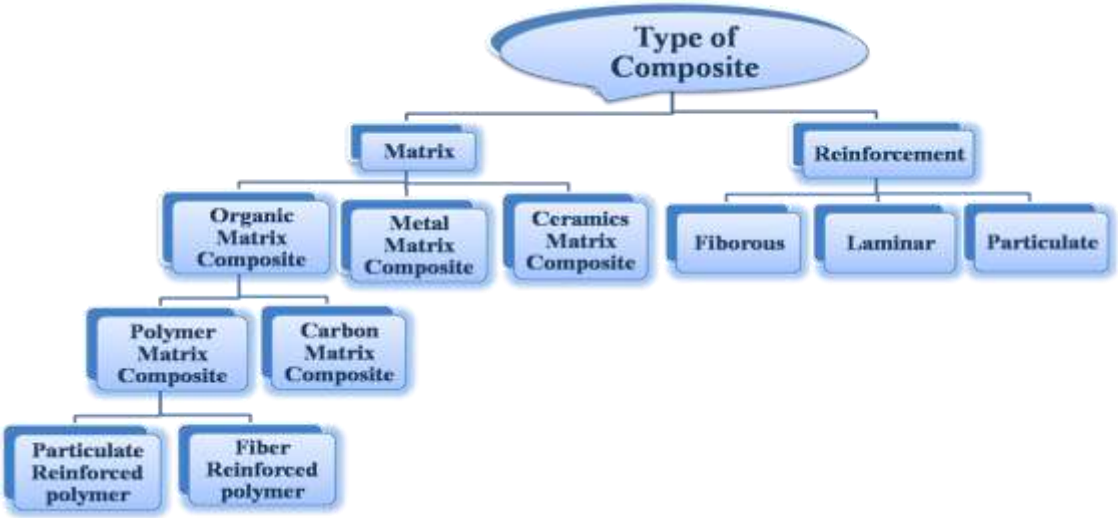

Fig. 1. Type of Composite

1) Flax

The biological name of the flax is name of Flax is linum usitatissmum. such a bast fiber which is used in development of the natural fiber, oil production and non-textile industries. It does not obtain from the roots or the capsular and seeds while it is obtained from the inner parts of the stem. Stem length is approx. 600 to 1000mm. In Fig.1.12(a) and 1.12(b) shows the flax plant and flax fiber after extraction and harvesting. back structure provided by the epidermis and cuticle on the outside due to requirement of decortications. Bundle of the fiber covered by the back structure. There is huge variation in the number of bundles.

Fig. 1.12(a) Flax Plants

Fig. 1.12(b) Flax Fiber

In plastic composition the flax fiber is ecologically safe material. Low density posed by the flax fiber comparatively the glass fiber and. Its having biodegradability, ecological in nature and not expensive. Flax fiber having more strength and toughness relatively than the glass.

2) Kenaf

Kenaf is a wild plant which grown up in the warm season, short day commonly occur in tropical and sub-tropical places like Asia and Africa. Around 4000 BC kenaf has been cultivated for the production of food and fiber by the extraction process. It has exclusive property that it contains long bast about 35% of stalk dry weight. It does not contain the hollow core instead of that it long bast with short core.it belong to the malvaceae family significant play a important role in the horticulture. In 4-5 months kenaf grown up to 4-6 m height. In a year 6000 to 10, 000 Kg/hrs. dry weighted kenaf fiber produced.

Kenaf comprises with the non-abrasiveness, biodegradables, low density and good specific mechanical properties. Properties of Kenaf are similar to the jute material. All the composition and the mechanical properties explain discussed in Table 1.1 and Table 1.2.

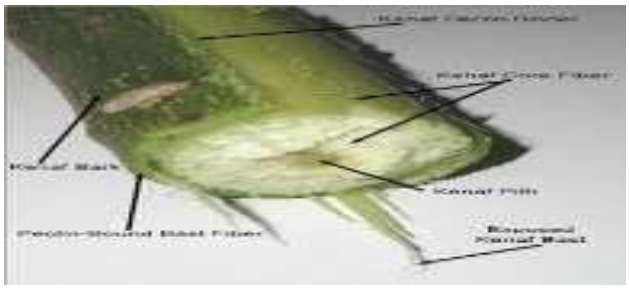

Fig. 1.13(a) Kenaf Plant

Fig. 1.13(b) Kenaf Fiber

3) Jute

The biological name of the jute fiber is Corchorus capsularis and Corchorus olitorius. Corchorus capsularis refers the white jute and Corchorus olitorius refer the dark jute. It is also obtained from the bast fiber. Quality and other characteristics depend upon the grades of the jute. In the world it achieved the second rank on the basis of cultivation while cotton have the first rank of cultivation. The growth of the jute fiber occurs in the monsoon season and every season growing plant. It achieved 2.5-4.5m height. Basically, it found in Bangladesh, India, Brazil and Indonesia.

Fig.1.14(a) Jute Plant

Fig. 1.14(b) Jute Fiber

II. LITERATURE REVIEW

Srinivasan and V. S (2014) investigate about the shear strength of the hybrid kenaf flax composite is better than the mono kenaf and flax composite material. he also investigated the flexural strength through scanning electron microscopy images in which cracking of the material analyzed on the 100 resolution. The variation of flexural strength finds out through the load verses displacement graph in between the GKFRP, GFFRP and GKFFRP composite material

Sharba (2013) researched that woven kenaf is better than the glass due its substantial static strength and fatigue strength in bidirectional plane. Hand layup technique used for the fabrication of the composite the specimen is cut according the ASTM standards. Woven kenaf possessed the bidirectional property which improve the sustainability of the material.

Mohaiman and Jet (2008) had investigated the various mechanical testing like flexural, tensile, fully reversed fatigue and compression testing on the kenaf fiber material at different alignment. Coefficient of fatigue degradation of composite enhanced by hybridizations of the unidirectional and woven Kenaf fiber.Thehybridization of the kenaf with glass in 30:70 weight ratios provides the good mechanical properties comparatively other hybridization of the kenaf and glass in weight ratio. Static and fatigue strength improved by the woven kenaf hybrid composite with the low weight and ecofriendly.

Sanjay and M. R. (2016) studied that hybridization of the glass in the jute and kenaf enhanced the mechanical properties by decreasing the voids. Hybridization of the E- glass jute/kenaf with epoxy matrix reduces the moisture absorption of the composite. There is one analysis done by the researcher by comparing the tensile test of hybridized jute glass (JF) and hybridized kenaf glass (KG). Hybridized kenaf glass having more tensile strength than the hybridized jute glass. From the SEM analysis it is observed that the failure of material obtained

CONCLUSION FROM LITERATURE REVIEW

Now a days, hybrid composite material used for various purpose in the industry. The natural fiber comprises with the different characteristics which enhance the mechanical and thermal properties of the composite material. the use of glass fiber mat, kenaf mat and flax mat as reinforcing material and thermosetting polymer as matrix is very economical and ecofriendly. From the literature survey the following points are extracted such as:

- Flax (Linum usitatissimum) has greater potential than the cotton and renewable resources, lower requirement of pesticides and artificial fertilizer grow with traditional farming process.
- Composite material has improved shear strength and natural frequency when the addition of percentage of flax material increase.
- There is variation in percentage of fiber reinforcement effect the mechanical properties of the material which improve its working capacity of the composite.
- Flax material having more wearing and resistive capacity than some other natural fiber, better mechanical and physical properties obtained by the kenaf material.
- Epoxy material possessed good mechanical properties and low boiling point.
- Interfacial characteristics analyzed by the scanning electron microscopy with the different -different resolutions which deal with the cause of breaking of the composite material like void content etc.
- With the help of above literature survey, it is concluded that the no work was done on the kenaf mat, glass mat and flax mat reinforced hybrid composite material with epoxy resin.

III. FABRICATION AND TESTING

Before the fabrication, following steps or processes are performed for retrieving the methodologies for the proper fabrication and testing of the hybrid composite material:

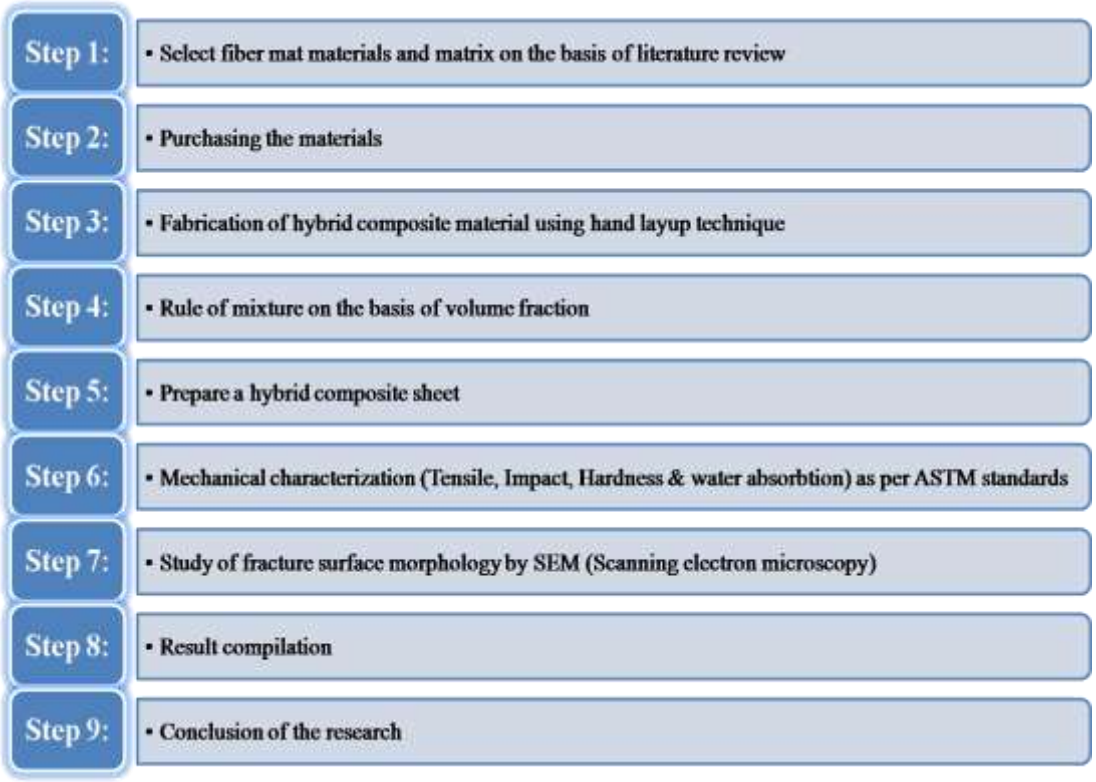

Fig. 3.1 Methodologies

A. MATERIAL REQUIRED

Hybrid composite material comprises with the incorporation of the natural fiber into the thermoset matrix which add their properties and remove the disadvantages of the material produce the required material. The set of natural fiber and thermoset matrix required for the preparation of the hybrid composite are as follows:

- Natural Fibers
- Kenaf mat
- Glass mat
- Flax mat
- Thermoset matrix
- Epoxy LY556
- Hardener HY951
- Wax
- Frame
- Mould
- C clamp Kenaf Mat

It belongs to the Hibiscus cannabinus family L. family Malvacea.It is obtained by the bast. It implants in the month of May to December grown up from 6-8 month achieve height of 5-6 m quickly at the 20-270 C temperature. It is harvested by hand and machine both. Its retting process is same as jute fiber. Plant stem is immersed into water for 7-14 days after that wash out with fresh water and dried out.

Cellulose	45–57 %
Hemicellulose	21.5 %
Lignin	8-13 %
Pectin	5-8 %

Fig.3:2 Kenaf Mat (00 / 900 Orientation)

Glass Mat

It is low alkali glass which contain 54 wt.% of silicon oxide ,14 wt.% of aluminum oxide, 22 wt.% of calcium and magnesium oxide, 10 wt.% of boron oxide and less than 2 wt.% of sodium

and potassium oxide.it is also known as alumina calcium borosilicate It is manufactures by the melt spinning technique. It is manufactured by the extrusion of thin silica gel with small diameter into various fiber. Due to its weight properties it is more favorable than the metals. Glass mat is produced by machine. E glass fiber have good dimensional stability, moisture resistance, specific properties, thermal properties, high tensile strength, good electric insulator. It is not affected by the organic solvent. It is opaque and transmission property ultra- violent towards violet transmission. Woven glass contains very fine fibers of the glass. Glass mat is bought through the Viruska Composite, Vijaybada

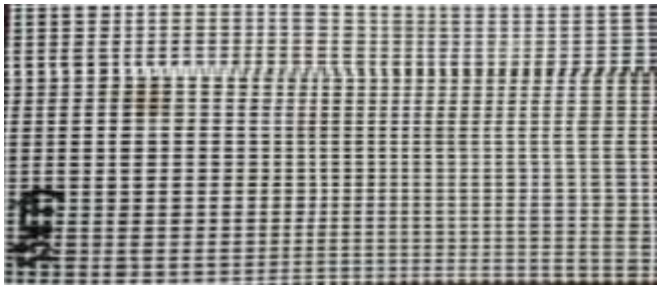

Fig. 3.3 E-Glass Mat (00 / 900Orientation)

Flax Mat

It is sown in month of march & April. Flax fiber is grown up in very short time period about in 100 days. It contains small branches and long fibers. The different steps are involved for the processing of the flax fiber like cultivation, harvesting, ripping, retting, scotching and hackling. It is procured by the Viruska Composite, Vijay Bada.

Cellulose	71%
Hemicellulose	18.6–20.6 %
Lignin	2-3%
Pectin	2.3%

Fig.2.4 Flax Mat (00 / 900 Orientation)

Thermoset Matrix

In the industry, the thermoset matrixes are most widely used. The thermoset matrices possess with the high mechanical strength, corrosive resistive, easily approachable temperature. It contains the high strength to weight ratio, chemical resistive character, high temperature tolerable capacity and good stiffness to weight ratio. It goes through change in the chemical reaction Sustainable recycling mechanism fulfilled by the hybrid composite due to low temperatures recyclability. Advantage of the thermoset is long time period processing i.e. thermoset used as fillers. 25 to above 1000C is the processing temperatures required for the fabrication, it below the degradation temperatures.

Epoxy Resin LY556

Epoxy is procured by the Singhal Traders, Meerut. It is the part of thermosetting resin. Araldite LY 556 epoxy manufactured by the Huntsman Advanced Materials which follow the certain properties which is used by the matrix materials

- Insulating capacity Easy to access
- Prolonged open time.
- Chemical resistive
- Provide good dimensional stability

For epoxy hardener as a preserving agent. Hardener work as a catalyst when combine with resin. It hardens the material due to evolution of heat by the exothermic reaction. The Mixing of epoxy with hardener provide the good characteristics for the environment. HY951 is used as a hardener in this experiment.it contain the 10-20MPa viscosity with 250C.

Fig. 3.5(a) Epoxy

Hardener HY951

It contains in the form of liquid. The hardener HY951 used for the preparation of the solvent which mixed with the resin produced the liquid solvent and work as binding agent.

Fig. 3.5(b) Hardener

Wax

A good quality wax is free from contaminations, gives out the balanced chemical reaction, nominal cost and can be precisely processed and having longer shelf life.

Wooden Frame

It is made of wood, cut down in the required shape of the mould so that the proper sheet of the composite is produced.

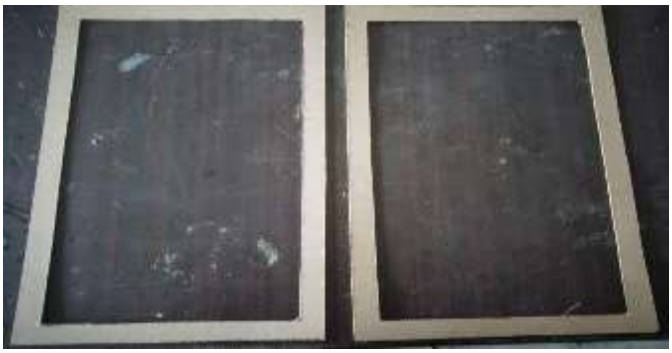

Fig. 3.6 Wooden Frame

Mould

Firstly, the mould is prepared for the manufacturing of the composite sheet so that the GKFHC sheet is prepared and further mechanical characteristics of the composite is estimate by using the different type of machine at their particulate required atmospheric condition.

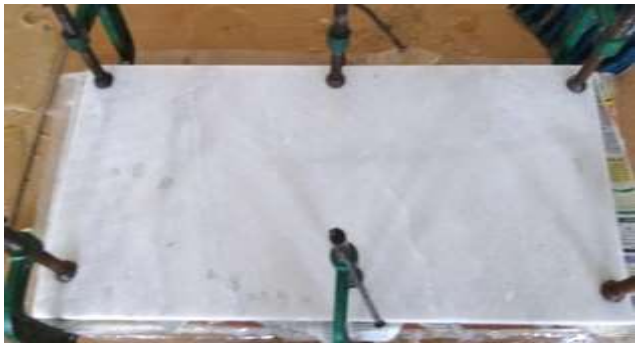

Fig. 3.7 Mould

C-Clamp

This equipment used for removing the air bubbles form the sheet, help in developing the good sheet. With the help of this clamp the appropriate pressure applied on the sheet so that the required sheet produced by removing all the uncertainty in the composite material.

Fig. 3.8 C Clamp

B. FABRICATION OF HYBRID COMPOSITE MATERIAL

Hand layup method is used for formulating hybrid composite material as shown in figure 5. Natural fiber is used as reinforcement and epoxy is used as matrix. To fabricate the mould of the dimension (600x300x10mm) with marble. Brush is used for cleaning the inner surfaces and other impurities. Initially, a release gel (wax) is scattered on the mould surface to evade the stabbing of epoxy on the surface Two wooden frame is prepared of having dimensions(420x240x5mm). Accumulate the mats of the glass, kenaf and flax and placed it on the mould longitudinally by 40% weight on the rule of mixture.

Mats are cut in the according to the mould size. Epoxy – hardener mixer is poured onto the surface of the mat which is located in the mould. One fiber mat is placed over the other surface of the mat. This process is continual after each layer of epoxy and mat until unless essential layer is stacked. C clamp is used with the mild pressure for removing any air stuck as well as additional epoxy remaining. After that fixed load is applied through the C-clamp and leave for the 48 hours Fabricated composite part is taken out from the mould at 55% humidity at room temperature Courtois and C., Demaison and J., Tawil and H. (1991)

Fig. 3.9(a) Final Composite Sheet

Fig. 3.9(b) Side View of Composite Sheet

Finally, the hybrid composite sheet is prepared having a dimension of (300×200×6) mm. It is characterized by the different mechanical parameters like tensile, impact, hardness and water absorption test. It is cut by the diamond tip hand cutter.

IV. MECHANICAL TESTING

1) Tensile Test
2) Impact Test
3) Hardness Test
4) Water Absorption Test

V. RESULT& DISCUSSION

Firstly, the there is a hybrid composite material manufactured after that the mechanical characterization was done as per different ASTM standards. The following testing done on the GKFHC hybrid composite material

1) Tensile test
2) Izod Test
3) Hardness test
4) Water absorption test
5) Density

A. TENSILE TESTING

Such a testing in which material controlled the tension until its failure is known as tension testing or tensile testing. This test help to find out the material qualities which help to decide the use of material in specialized application and quality control. It estimates about the material reaction during the type of force, amount of force, peak load etc. During the testing the specimen are cut accordance the ASTM D339.

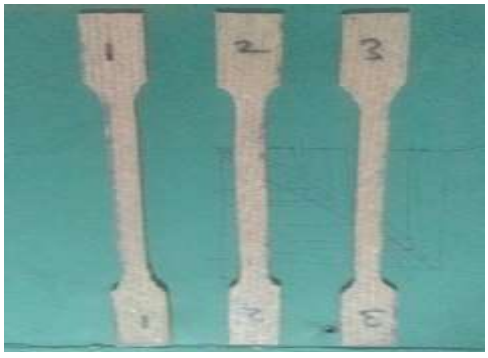

Fig. 5.1(a) Specimen before Fracture

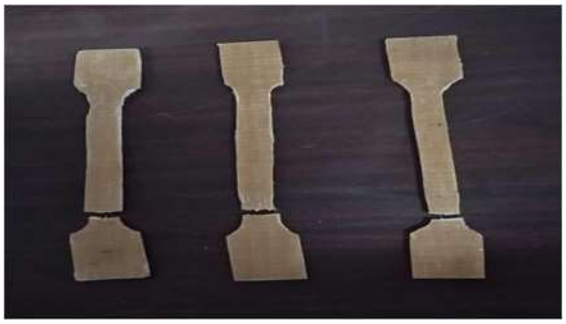

Fig. 5.1(b) Specimen after Fracture

Thereafter the Fig. 5.1(a) and Fig. 5.1(b)show the specimen before and after the fracture of the composite material.

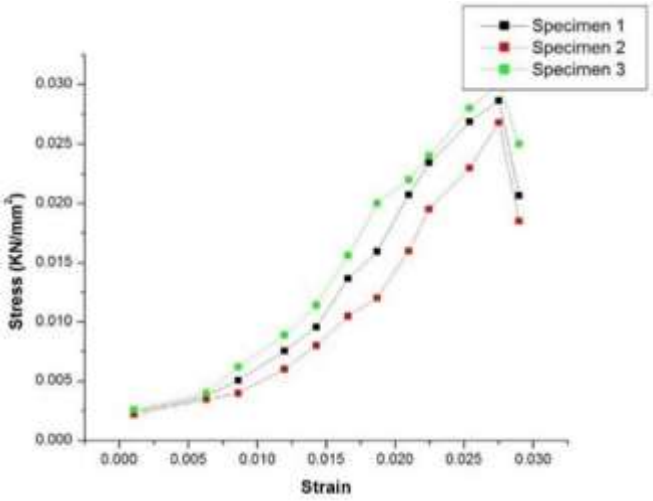

Fig. 5.2 Stress Strain Curve

Summary of Tensile Test

From the tensile test the ultimate tensile strength, young's modulus and elongation percentage is determine by using the UTM machine (AST 40) and the following result obtained from the testing.

Mean Value of Ultimate tensile strength = 27 MPa
Mean Value of Elongation = 52.37 %
Mean Value of young modulus = 330 MPa

Sr.no.	Composite material	Tensile strength (MPa)
1.	Jute+ Banana+ Glass	22.76
2.	Banana+ Glass+ Jute	20.93
3.	Jute+ Sisal+ Glass	22.29

B. IMPACT TEST

Such a test in which the shock absorbing capacity measured is termed as impact testing. During the impact testing the sudden load applied on the specimen, absorbing of this shock stored in the form of impact energy.

Fig. 5.3(a)Specimen before Fracture

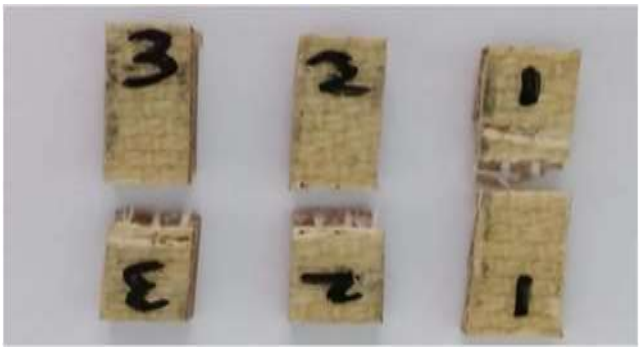

Fig. 5.3(b)Specimen after Fracture

Summary of Impact Testing

In the following table the summary of impact strength is given. Three different reading was estimated from the Izod impact test as per the ASTM standards. Impact energy measured in the form of J/s.

Table 5.1 Summary of Impact Testing

S.No	Name of the Specimen	Testing Method	Test Value
1	Specimen 1	ASTM-D256	63.5
2	Specimen 2	ASTM-D256	63.8
3	Specimen 3	ASTM-D256	62.85

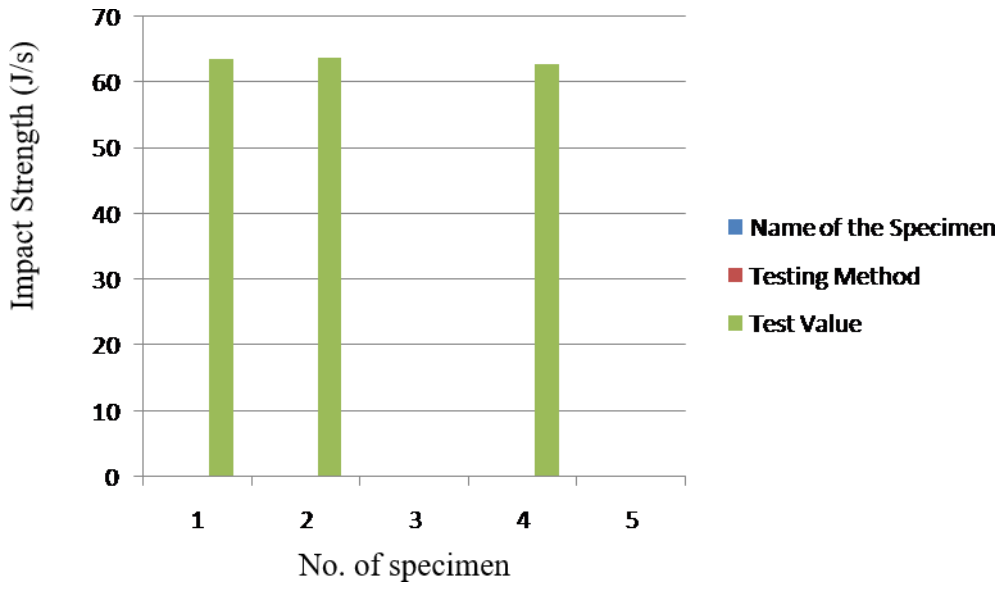

Fig. 5.4 Impact Testing

Mean Value of Material strength = 63.33 J/m

Impact strength of the hybrid composite material obtain from the Izod test at the ASTM D256 standards from the value of the impact strength of the hybrid composite material is 63.33 J/m. the mean value of the hybrid composite material possessed high impact strength than the epoxy material and other hybrid composite materials. In the below table there is comparisons of the impact strength estimated with the different categories of the hybrid composite material.

Table 5.2 Hybrid Composite Material

Sr.no.	HYBRID COMPOSITE MATERIAL	IMPACT STRENGTH
1.	Sisal +Epoxy	2.55 J/mm^2
2.	Jute +Epoxy	3.15 J/mm^2
3.	Sisal+ Rice husk	2.98 Joule
4.	Jute + Banana + Glass	9 Joule

C. HARDNESS TEST

Digital hardness test machine helps to find out the hardness of the hybrid composite material as shown in figure. Hardness test perform on the M scale. i.e. HRM scale. There is some step must be adopted during the hardness testing of the specimen who is as follows:

i. First of all, select the indenter i.e. 1/14-inch hardened steel ball type.
ii. After that the 100Kgf load selected for applying on the specimen.
iii. HRM scale fixed by the on the digital hardness testing machine.
iv. Minor load applied on the specimen which having maximum capacity about the 300Kgf.
v. Set the zero point on the machine before the starting.
vi. After that load applied on the workpiece.
vii. Dual time is zero and load is relief.
viii. Finally, hardness number notified on the screen.

Fig. 5.5 Digital Hardness Machine before the Testing

Fig. 5.6 Digital Hardness Machine after the Testing

Summary of Hardness Test

Hardness testing reading obtains from the digital hardness testing machine on the M scale by using the specific indenter. Three different reading was obtaining from the different specimen through which mean value obtained is 62.33. it is dimensionless quantity.

It possessed the good hardness comparatively other hybrid composite material. the value obtained during the testing is shown in the following table 5.3

Table 5.3 Sample with Reading

Sr.no.	SAMPLE NUMBER	READING
1.	Sample 1	62
2.	Sample 2	63
3.	Sample 3	62

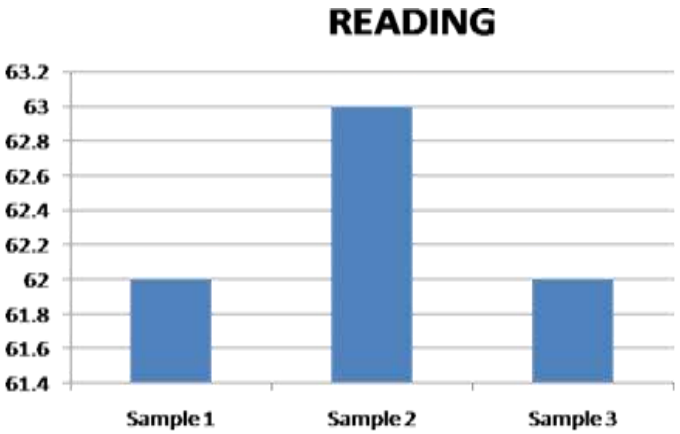

Fig. 5.7 Hardness Test

Average hardness of Composite = 62.33 HRM

D. DENSITY OF GKFHC

Three hybrid composites specimens were cut as per test standards which is square shape with dimension 60x40x5 mm. The volume was calculated from the measured dimension. The all hybrid composites specimens' density was then recorded. Density was measured by using ASTM D 1895 standard [59]. The density of hybrid composites – 0.806 gm/cm3

E. WATER ABSORPTION TEST

The water absorption depends upon the various factors which are as follows:

- Fibre Orientation
- Volume Fraction
- Humidity
- Immersed Surface Area
- Matrix Viscosity
- Temperature
- Voids on surface protection

When the workpiece completely immersed in the different type of water shows the variation in change in weight due with the varying time period. There is different type of water used for testing such as:

- Sea water
- Borewell water
- Distilled water

Table 5.4 Water Absorption in Sea Water

Sr.no.	Change in weight (grams)	Time (hrs.)
1.	0.25	3
2.	0.45	4
3.	0.65	5
4.	0.85	6
5.	0.87	7
6.	0.95	8

Table 5.5 Water Absorption in Borewell water

Sr.no.	Change in weight (grams)	Time (hrs.)
1.	0.3	3
2.	0.5	4
3.	0.7	5
4.	0.9	6
5.	0.95	7
6.	1	8

Table 5.6 Water Absorption in Pure Water

Sr.no.	Change in weight (grams)	Time (hrs.)
1.	0.4	3
2.	0.6	4
3.	0.8	5
4.	1	6
5.	1.1	7
6.	1.15	8

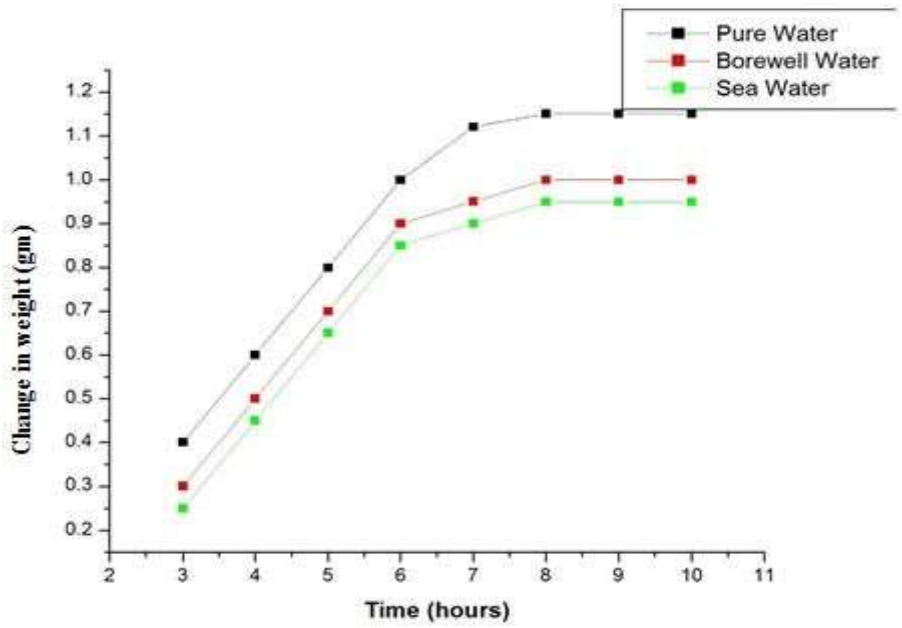

Fig. 5.10 Water Absorption Test

From the above graph it could be analyzed that in pure water maximum water absorbed by the specimen, after that the borewell water and then the sea water. Reading of water absorption takes place after a specific time interval.

VI. CONCLUSIONS

There is development of the hybrid composite material consist with the natural fiber (Kenaf mat & flax mat) by mixing with the polymer matrix (epoxy resin and araldite hardener) and after that the mechanical characterization occur in which tensile test, impact test, hardness test, density and water absorption test takes place. The entire specimen prepared as per the specific ASTM standards.

- The present investigation a hybrid composite (GKFHC) is made with polymer matrix (Epoxy Resin). Various mechanical tests are performed as per ASTM standards.
- Fabrication of multifaceted reinforced hybrid composite material successfully operated with thermosetting epoxy resin matrix and light weight and ecofriendly natural fiber (kenaf and flax) with the glass fiber.
- Percentage of reinforcement and fiber orientation describe strength of the hybrid composite material at room temperature.
- As per the orientation, yielding of GKFHC composite material is better than the single natural fiber of either only kenaf or flax reinforced composite material. GKFHC follow 00 and 900 orientation.
- There is 22.48% increase in Ultimate tensile strength of GKFHC Composite(27MPa) by adding kenaf and flax fiber with glass in comparison to Banana and jute with the glass fiber natural hybrid composite and 13.7% greater than the jute/sisal/glass. [66- 67]
- The impact strength of the GKFHC (63.33J/m) is 85.78% increase than the jute/banana with the glass fiber [68].
- The maximum amount of water absorbed by the pure water. The hybrid composite material GKFHC have low water absorption rate than the individually woven composite material. The water absorption rate depends upon the cellulosic and hemi cellulosic content. The GKFHC composite absorbed water up to its saturation point, after that the absorption of water did not takes place until it immersed in the water for the infinite time period. [69-70]
- Density of GKFHC composite is 0.8067 gm/cm3 which is very less than other glass fiber composite
- There is improvement (25.12%) in hardness of GKFHC Composite (62.33) in comparison to Bagasse and coconut coir glass fiber natural hybrid composite.
- SEM analysis shows the interfacial relationship between the fiber and matrix. fiber is orderly distributed in the matrix and clear pull out, impartiality of reinforced fibers. The fracture morphology accomplished, appears to involve both fibers pull out and fiber breaking as well as micro-crack of matrix.
- It was found that these hybrids composite material replace the synthetic fiber composite material for moderate loading which significantly reduce the problem of environment.
- Finite element method provides appropriate path to estimate mechanical, thermal properties of the composite material before its actual manufacturing. Relevant properties give the basic description and its outcomes after manufacturing at that particular data. Addition of different type of material can be done easily without the manufacturing cost and expenses.

VII. FUTURE SCOPE

Natural fiber reinforced hybrid composite material has wide scope for future investigation. High specific strength to weight ratio, low density, biodegradability etc. various factor which enhance its quality. For future search some recommendation are as follows:

- Fabrication of hybrid composite material obtained by use of different natural fiber like seed fiber, leaf fiber etc. with the glass fiber and thermosetting matrix with different volume fraction ratio.
- Mechanical and machining properties of the material can be estimated by adding different potential natural fiber as reinforcing element with different orientation and different volume fraction ratio.
- Characterize the mechanical properties of hybrid composite material at different orientation and stacking sequences like 00 and 450, 300 and 600 etc.
- Tribological behavior and fatigue etc. other relevant properties may be find out by using different experimental set up.
- Experiment can be extended out by various machining parameters, like geometry tool, material of the tool, feed rate etc.
- Hybrid composite provides the thrust area for the examination of mechanical and damage behavior of the composite.
- Other modeling technique used for analyzing the experimental data like fuzzy logic, solid works, ANFIS etc.
- With the help of FEM analysis various other mechanical, thermal, properties can be estimated economically.
- Analysis of one type hybrid composite material can be performed by using different module in the ANSYS like solid works, ACP etc.

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