FABRICATION AND TESTING MECHANICAL BEHAVIOUR OF JUTE FIBRE AND ALUMINIUM COMPOSITE MTERIALS

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Abstract - *A composite material is made from two or more constituent materials; having better properties compared two both two parent materials. The composite is stronger, lighter, and less expensive compared with the traditional materials. In current years composites have considerable importance as a potential operational material. Low cost, light weights, high specific modulus, renewability and biodegradability are the most basic and common attractive features of composites that make them useful for industrial applications. With low cost, high specific mechanical properties natural fiber signifies a worthy renewable and biodegradable composite. Among those kenaf, flax and its hybrid fibers. The present work has been done with an objective to explore the use of kenaf fiber, flax fibre and its combinations (hybrid) are used as a reinforcement material in epoxy base, final find out the mechanical properties like tensile, hardness, impact and grain structure of kenaf fiber, flax fiber and its combination (hybrid) composites.*

***KeyWords*:** Aluminium Powder ,Kenaf fiber, Flax fiber, Hybrid Fiber, Tensile test, hardness test,Impact test, Grain structure,

1: INTRODUCTION

A "Composite" can be defined as where two or more different materials are physically combined together. Two constituent materials which are having different mechanical, physical and chemical properties are bonded will produce a material with different characteristics from the individual material is called a composite material. The two constituents are reinforcement and matrix .The reinforcement and matrix are the main load carrying elements in a composite material. This matrix can maintain the alignment of fiber, shape and from environmental fortify. The reinforcement can improve the strength of the material.

The properties of composite material are exhaustion life, electrical protection, wear resistance, warm protection quality, light weight, solidness, warm conductivity, fire resistance, temperature-subordinate conduct, and warm protection. The utilization of composite materials is very long. These composite materials are renewable biodegradable. Composite materials have good fatigue resistance compared to other metals. Low radar visibility and Molding to complex forms of composites are easy compared to other materials. The wide use of composite materials in surface transportation is because of their huge size. The strength-weight ratio is higher than other materials which results in the effective use of composite materials in surface transportation. Resilience and good productivity are the basic required qualities of a good composite material.

Composite materials can be classified in different ways. Classification based on the geometry of a representative unit of reinforcement is convenient since it is the geometry of the reinforcement which is responsible for the mechanical properties and high performance of the composites.
A typical classification is
The two broad classes of composites are
(1) Particulate composites
(2) fibrous composites.

PARTICULATE COMPOSITES

As the name itself indicates, the reinforcement is of particle nature (platelets are also included in this). It may be spherical, cubic, tetragonal, a platelet, or of other regular or irregular shape, but it is approximately or roughly equiaxed or equal in shape. Thus, particulate-reinforced composites include those reinforced by spheres, rods, flakes, and many other shapes of roughly equal axes. In general, particles are not very effective in improving fracture resistance but they enhance the stiffness of the composite to a limited extent. Particle fillers are widely used to improve the properties of matrix materials such as to modify the thermal and electrical conductivities, improve performance at elevated temperatures, reduce friction, increase wear and abrasion resistance, improve mach inability, increase surface hardness and reduce shrinkage.

FIBROUS COMPOSITES

A fiber is characterized by its length being much greater compared to its cross- sectional dimensions. The dimensions of the reinforcement determine its capability of contributing its properties to the composite. Fibers are very effective in improving the fracture resistance of the matrix since a reinforcement having a long dimension discourages the growth of incipient cracks normal to the reinforcement that might otherwise lead to failure, particularly with brittle matrices.

Man-made filaments or fibers of non polymeric materials exhibit much higher strength along their length since large flaws, which may be present in the bulk material, are minimized because of the small cross-sectional dimensions of the fiber. In the case of polymeric materials, orientation of the molecular structure is responsible for high strength and stiffness.

Fibers, because of their small cross- sectional dimensions, are not directly usable in engineering applications. They are, therefore, embedded in matrix materials to form fibrous composites. The matrix serves to bind the fibers together, transfer loads to the fibers, and protect them against environmental attack and damage due to handling. In discontinuous fiber reinforced composites, the load transfer function of the matrix is more critical than in continuous fiber composites.

COMPONENTS OF A COMPOSITE MATERIAL

In its most basic form a composite material is one, which is composed of at least two elements working together to produce material properties that are different to the properties of those elements on their own. In practice, most composites consist of a bulk material (the matrix) and a reinforcement of some kind, added primarily to increase the strength and stiffness of the matrix.

(a) Bulk Phases

1. POLYMER MATRICES

A very large number of polymeric materials, both thermosetting and thermoplastic, are used as matrix materials for the composites.

Polymer Matrix Composite is the material consisting of a polymer (resin) matrix combined with a fibrous reinforcing dispersed phase. Polymer Matrix Composites are very popular due to their low cost and simple fabrication methods.

Use of non-reinforced polymers as structure materials is limited by low level of their mechanical properties: tensile strength of one of the strongest polymers - epoxy resin is 20000 psi (140 M Pa). In addition to relatively low strength, polymer materials possess low impact resistance

Resin systems such as epoxies and polyesters have limited use for the manufacture of structures on their own, since their mechanical properties are not very high when compared to, for example, most metals. However, they have desirable properties, most notably their ability to be easily formed into complex shapes. Materials such as glass, aramid and boron have extremely high tensile and compressive strength but in 'solid form' these properties are not readily apparent. This is due to the fact that when stressed, random surface flaws will cause each material to crack and fail well below its theoretical 'breaking point'. To overcome this problem, the material is produced in fiber form, so that, although the same number of random flaws will occur, they will be restricted to a small number of fibers with the remainder exhibiting the material's theoretical strength. Therefore a bundle of fibers will reflect more accurately the optimum performance of the material. However, fibers alone can only exhibit tensile properties along the fiber's length, in the same way as fibers in a rope.

It is when the resin systems are combined with reinforcing fibers such as glass, carbon and aramid that exceptional property can be obtained. The resin matrix spreads the load applied to the composite between each of the individual fibers and also protects the fibers from damage caused by abrasion and impact. High strengths and stiffness, ease of moulding complex shapes, high environmental resistance all coupled with low densities, make the resultant composite superior to metals for many applications. Since PMC's combine a resin system and reinforcing fibers, the properties of the resulting composite material will combine something of the properties of the resin on its own with that of the fibers on their own.

Polymers make ideal materials as they can be processed easily, possess lightweight, and desirable mechanical properties. It follows, therefore, that high temperature resins are extensively used in aeronautical applications.

Two main kinds of polymers are thermosets and thermoplastics. Thermosets have qualities such as a well-bonded three-dimensional molecular structure after curing. They decompose instead of melting on hardening. Merely changing the basic composition of the resin is enough to alter the conditions suitably for curing and determine its other characteristics. They can be retained in a partially cured condition too over prolonged periods of time, rendering Thermosets very flexible. Thus, they are most suited as matrix bases for advanced conditions fiber reinforced composites. Thermosets find wide ranging applications in the chopped fiber composites form particularly when a premixed or moulding compound with fibers of specific quality and aspect ratio happens to be starting material as in epoxy, polymer and phenolic polyamide resins.

Thermoplastic have one-or two-dimensional molecular structure and they tend to at an elevated temperature and show exaggerated melting point. Another advantage is that the process of softening at elevated temperatures can reversed to regain its properties during cooling, facilitating applications of conventional compass techniques to mould compounds.

Resins reinforced with thermoplastics now comprised an emerging group of composites. The theme of most experiments in this area to improve the base properties of the resins and extract the greatest functional advantages from them in new avenues, including attempts to replace metals in die-casting processes. In crystalline thermoplastics, the reinforcement affects the morphology to a considerable extent, prompting the reinforcement to empower nucleation. Whenever crystalline or amorphous, these resins possess the facility to alter their creep over an extensive range of temperature. But this range includes the point at which the usage of resins is `constrained, and the reinforcement in such systems can increase the failure load as well as creep resistance.

2. METAL MATRICES

Metal matrix composites possess some attractive properties, when compared with organic matrices. These include (i) strength retention at higher temperatures, (ii) Higher transverse strength, (iii) Better electrical conductivity, (iv) Superior thermal conductivity, (v) Higher erosion resistance (vi) Improvement in low temperature creep (vii) Reduction in thermal elongation etc. However, the major disadvantage of metal matrix composites is their higher densities and consequently lower specific mechanical properties compared to polymer matrix composites. Another notable difficulty is the high-energy requirement for fabrication of such composites & sometimes development of magnetic properties.

3. CERAMIC MATRICES

Ceramic fibers, such as alumina and SiC (Silicon Carbide) are advantageous in very high temperature applications, and also where environment attack is an issue. Since ceramics have poor properties in tension and shear, most applications as reinforcement are in the particulate form (e.g. zinc and calcium phosphate). Ceramic Matrix Composites (CMCs) used in very high temperature environments, these materials use a ceramic as the matrix and reinforce it with short fibers, or whiskers such as those made from silicon carbide and boron nitride.

(a) Reinforcement

The role of the reinforcement in a composite material is fundamentally one of increasing the mechanical properties of the neat resin system e.g. in a continuous fiber-reinforced composite, the fibers provide virtually all of the strength and stiffness. For most of the applications, the fibers need to be arranged into some form of sheet, known as a fabric, to make handling possible. Different ways for assembling fibers into sheets and the variety of fiber orientations is possible to achieve different characteristics.

b) Interface

It has characteristics that are not depicted by any of the component in isolation. The interface is a bounding surface or zone where a discontinuity occurs, whether physical, mechanical, chemical etc. The matrix material must “wet” the fiber. Coupling agents are frequently used to improve wet ability. Well "wetted" fibers increase the interface surfaces area. To obtain desirable properties in a composite, the applied load should be effectively transferred from the matrix to the fibers via the interface. This means that the interface must be large and exhibit strong adhesion between fibers and matrix. Failure at the interface (called deboning) may or may not be desirable.

TYPES OF COMPOSITE MATERIALS

Fiber-Reinforced Composites

Reinforced-composites are popularly being used in many industrial applications because of their inherent high specific strength and stiffness. Due to their excellent structural performance, the composites are gaining potential also in tribological applications. In this type composite the second phase is in the form of fibers dispersed in the matrix which could be either plastic or metal. The volume fraction (vf) varies from a few percentage to as high as 70%. Usually the fiber reinforcement is done to obtain high strength and high modulus. Hence it is necessary for the fibers to posses' higher modulus than the matrix material, so that the load is transferred to the fiber from the matrix more effectively.

Dispersion Hardened Material

In this type of material, fine particles of sizes ranging from 0.01μm to 0.14μm are dispersed in matrix. Their concentration varies from 1% to 15% by volume. These fine particles impede dislocation movement in the material and therefore result in very high strength. Also these materials posses improved high temperature strength and creep resistance.

1.4.3 Particulate composite

In this type of composites, 1μm to 200μm size particles are dispersed in the matrix and volume fraction is generally between 0.01 Vf to 0.85 Vf..

Particulate composites consist of a matrix reinforced with a dispersed phase in form of particles. Effect of the dispersed particles on the composite properties depends on the particles dimensions.

Particulate-filled materials consisting of a continuous matrix phase and a discontinuous filler phase made up of discrete heterogeneous particles are simulated by an elementary model consisting of a single spherical particle embedded in an infinite matrix, the particle being constituted by a spherical core within a concentric spherical shell. The specific case studied is one in which the particle core and matrix are of the same glassy polymer, and particle shell is a rubbery material. The distributions of six suggested craze initiation factors in the region surrounding the single particle are calculated when the material is subjected to a uniform uniaxial tension at infinity. Results indicate that the critical regions for craze formation are located either at the pole or at the equator of the particle (the polar axis being parallel to the applied tension), depending on the criterion considered and on the relative size of the glassy core in the particle.

FLAX:

Flax also known as linseed. Its binomial name is linum lisitssimum. Flax comes under the family of Linacease. Flax was extensively cultivated in ancient egypt. Flax grows to 1.2 m tall with slender stems with 20-40 mm long and 3mm broad. The leaves are in glaucous green colour.

Flax fiber Properties

Property	Unit	Value
Density	g/cm³	1.40
Tensile strength	MPa	1034
Tensile modulus	GPa	51.0
Elongation at break	%	1.5

KENAF:

Kenaf is a plant in the family Malvaceae also called Deccan hemp and Java jute. Hibiscus cannabinus is in the genus Hibiscus and is native to southern Asia, though its exact origin is unknown. The name also applies to the fibre obtained from this plant. Kenaf is one of the allied fibres of jute and shows similar characteristics.

Kenaf fiber Prope rties

Kenaf properties	*Unit*
Diameter of fibre (microm)	55.27 (avg)
Density (g/cm3)	1.222
Tensile modulus (GPa)	51.98
Tensile strength (MPa)	504.78
Specific modulus $(m/s)^2$	42.5×10^6
Specific strength (kNm/kg)	413.1
% elongation at break (%)	9.8

HARDENER ARALDITE HY951:

Hardener was used as a binder during the fabrication. It has low viscosity, cure at room temperature, good mechanical strength, Good resistance to atmospheric and chemical degradation

EPOXY RESIN:

Epoxy has good additive properties along with high mechanical strength, low shrinkage, chemically resistant, high diffusion density, low viscous and better electric insulation capacity. And it is easily reinforced with natural flax, kenaf and hybrid fibers.

Araldite (LY556)

Product type	Epoxies – Bisphenol-A based
Chemical composition	Bisphenol-A-based epoxy resin
Aspect (visual)	Clear, pale yellow liquid
Viscosity at 25°C	10,000–12,000 mPa s
Density at 25°C	1.15–1.20 g/cm^3

ADVANTAGES OF NATURAL FIBRE COMPOSITES

In it simplest definition natural fibres are sourced from plants or animals, meaning they are not synthetic or manmade. Natural fibres can come from a large variety of fibre sources:

- Bast fibres: Jute, flax, hemp, kenaf, bamboo
- Seed fibres: Cotton, coir, kapok
- Leaf fibres: Sisal, pineapple, banana, abaca, palm
- Grass and reed fibres: Rice, corn, wheat
- Core fibres: Hemp, kenaf, jute

When it comes to the properties of the natural fibres, it is important to state that difference occurs when choosing one type of fibre over another. The performance of the composite depends on many factors such as structure, mechanical composition, physical properties, cell dimensions, microfibrillar angle etc. Here natural fibres contain low cost, density and weight, less pollution during production resulting in minimal health hazards and eco-friendly nature. Composites reinforced with natural fibres also have a short lifetime when it comes to degradation with limited environmental damage whereas synthetic fibres have a negative impact due to degradation pollution.

ASPECTS OF THE PROPOSED RESEARCH WORK:

The proposed investigation work is to investigate the advantages of using the trademark fiber as reinforced material in composites. The examination work gives the central information and perception of the behavior and response of typical fiber. Diverse parts of basic filaments have been explored. Preparation of characteristic fiber-Extraction of fiber, kenaf and flax Tensile properties and -kenaf fiber composite specimens, according to ASTM guidelines.

Tensile properties-flax composite specimens, according to ASTM guidelines.

Tensile properties-Hybrid fiber composites specimens, according to ASTM guidelines.

Hardness properties-kenaf fiber composite specimens, according to ASTM guidelines.

Hardness properties- flax fiber, according to ASTM guidelines.

Hardness properties- Hybrid fiber composite.

Impact properties-kenaf fiber composite, flax fiber composite specimens, according to ASTM guidelines.

Impact properties-kenaf fiber composite specimens, according to ASTM guidelines.

Impact properties-Hybrid fiber composite, according to ASTM guidelines.

FABRICATION OF COMPOSITES

FABRICATION OF COMPOSITE SPECIMENS

(HAND LAYUP):

Hand lay-up technique is the simple and cheapest method of composite processing. The infrastructural need for this technique is also minimal .The standard test procedure for Mechanical properties of fiber-resin composites; ASTM-D790M-86 is utilized to according to the measurements.

The mold is prepared on smooth clear film with 2 way tape to the required measurement. At that surface mold is prepared keeping the 2 way tape on the clear film. The reinforcement in the form of long fiber are cut as per the mold size and placed on the surface of thin plastic sheet. Then the thermosetting polymer in liquid form is assorted thoroughly in appropriate proportion with a recommended hardener (curing agent) and poured on the surface of clear .The polymer is uniformly spread with the help of brush. Then second layer of fiber is placed on the polymer surface and another layer of polymer is applied after this is closed with another thin plastic sheet after squeezer is moved with a gentle pressure on the thin plastic sheet to remove air .The consequential mold is cured for 24 hours at room temperature.

Al powder is mixed with epoxy resign and stirred uniformly half and hour and same process is follow to produce Al composites the ASME statndards165mm long, 12.5mm in width and 4mm in thick are fabricated for tensile testing. 100mm long, 25mm width and 4mm in thick are fabricated for flexural testing. 63.5mm long, 12.36mm width and 6mm thick are fabricated for impact testing.

ALKALI TREATMENT:

Kenaf and flax fibers were soaked in 5 and 5 (wt)% of NaOH solutions at 25°C for 7 h, maintaining a liquor ratio of 15:1. The fibers were washed for several times with distilled water to remove any alkali solution sticking on their surface, after fiber are dried in sun light as shown below figures.

figure 4.1 FIBER PREPARATION

TESTING OF COMPOSITES:

TENSILE TESTING OF COMPOSITES:

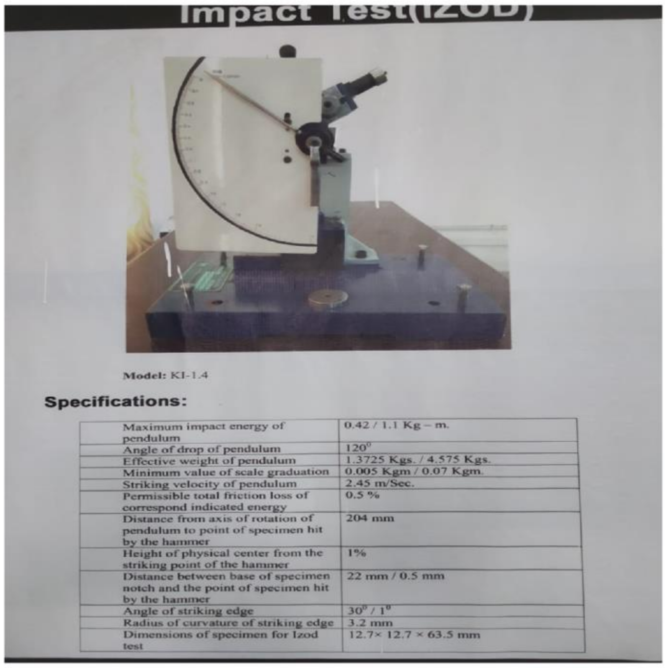
A 2 ton limits electronic tensometer, METM 2000 ER-1 model (Plate II-18), supplied by M/S microtech Pune, is used to determine the elasticity of composites. Its capability can be changed by burden cells of 20 kg, 200 kg and 2 ton. A burden cell of 2 ton is used for testing composite specimens. Self-adjusted brisk grasp throw is used to hold composite specimens. A computerized micrometer is used to measure the required thickness and width of composite specimens. The gauge length, width and thickness are measured with 0.001 mm minimal tally computerized micrometer. This electronic tensometer is fixed with burden and augmentation pointers, which has a minimal tally of 0.01 kg and 0.01mm individually. An electronic tensometer is fitted with an altered self adjusted snappy grasp toss and other versatile self adjusted fast hold toss to hold 16 mm wide and 8 mm thick specimens. Specimens are placed in the grips of a tensometer at a specific grip separation and subjected to load until failure. The force applied is varied on to quantify the heap and expansion of specimen. The flexible throw is further moved such that the heap pointer just begins giving evidence stacking on the specimen. Right then and there the expansion meter is acclimated to peruse zero, when the heap on the example is zero.

Tensile Test Specimens before testing

IMPACT TESTING OF COMPOSITES:

Standard test procedure, ASTM D256-97, for effect properties of fiber composites has been used to examine the unidirectional composite specimens. The specimens to be examined are of dimensions 63.5mm long, 12.36mm wide and 10mm in thick. A V-point is placed in impact tester record having an included point of 450 at the focal point of the specimen, and at 90¬¬0 to the specimen pivot. The profundity of the specimen to be examined under the indent is 2 mm.

The examination assembles with ASTM standard gauges. Based upon the volume portion of the specimen, one of the four sledges (R11, R2, R3, and R4) must be chosen to break the specimen. The sledge is fixed to the pendulum in a specific manner that it will reach the specimen on a line 22mm over the top surface. The specimen is fixed to the anvil and hammer is used to break the specimen. The pendulum sledge is released from locking position which is at a point of 1500 and hits the specimen with a striking speed of 2.46m/sec. The specimen is stripped and energy is demonstrated in joules by the pointer on the particular scale.



Impact test Specimens before testing

HARDNESS TEST :

Hardness is a measure of the resistance to localized plastic deformation induced by either mechanical indentation or abrasion. Some materials (e.g. metals) are harder than others (e.g. plastics, wood). Macroscopic hardness is generally characterized by strong intermolecular bonds, but the behavior of solid materials under force is complex; therefore, there are different measurements of hardness: scratch hardness, indentation hardness, and rebound hardness.

Hardness test Specimens before testing

Grain structure

Microstructure is the very small scale structure of a material, defined as the structure of a prepared surface of material as revealed by an optical microscope above 25× magnification. The microstructureofmaterial(suchas metals, polymers, ceramics or composites) can strongly influence physical properties such as strength, toughness, ductility, hardness, corrosion resistance, high/low temperature behaviour or wear resistance. These properties in turn govern the application of these materials in industrial practice.

Microstructure at scales smaller than that can be viewed with optical microscopes is often called nanostructure, while the structure in which individual atoms are arranged is known as crystal structure. The nanostructure of biological specimens is referred to as ultrastructure. A microstructure's influence on the mechanical and physical properties of a material is primarily governed by the different defects present or absent of the structure. These defects can take many forms but the primary ones are the pores. Even if those pores play a very important role in the definition of the characteristics of a material, so does its composition. In fact, for many materials, different phases can exist at the same time. These phases have different properties and if managed correctly, can prevent the fracture of the material.

Grain structure specimens

RESULT AND DISCUSSION:-

Tensile test results:

TENSILE TEST	LOAD	ELONGATION
KENAF FIBRE	1932	5.04
KENAF+FLAX	1167	2.85

HYBRID FIBRES		
FLAX FIBRE	951.3	3.37
HYBRID+10%AL	1490.7	4.20
HYBRID+20%AL	1520.5	5.08
HYBRID+30%AL	2716.5	6.72

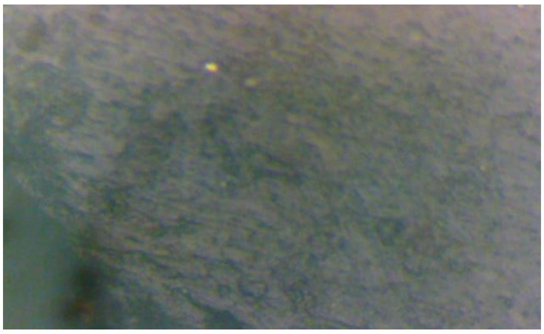
Impact test results:

IMPACT TEST	NEWTONS
KENAF	0.5
FLAX	0.3
KENAF + FLAX(HYBRID)	0.6
HYBRID+10%AL	0.4
HYBRID+20%AL	0.6
HYBRID+30%AL	0.8

Hardness Test Results:

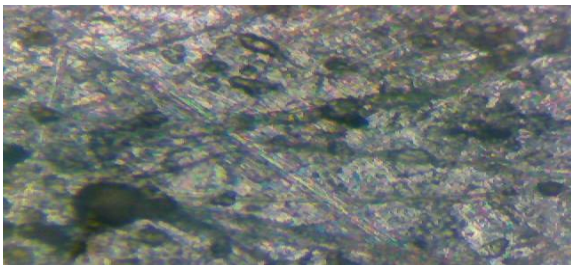
HARDNESS TEST	DEPTH OF INDENTATION
KENAF	31
FLAX	28.5
KENAF + FLAX(HYBRID)	30.5
HYBRID+10%AL	23
HYBRID+20%AL	30
HYBRID+30%AL	33

Grain Structure Results:

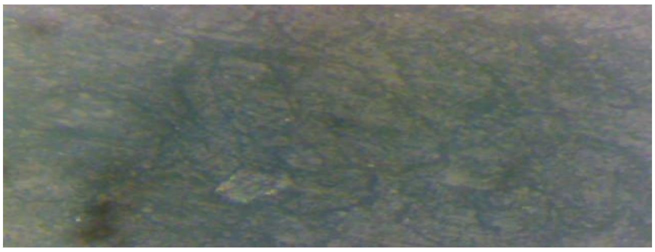


100%KENAF

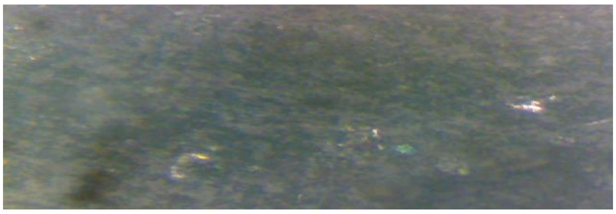
100%FLAX



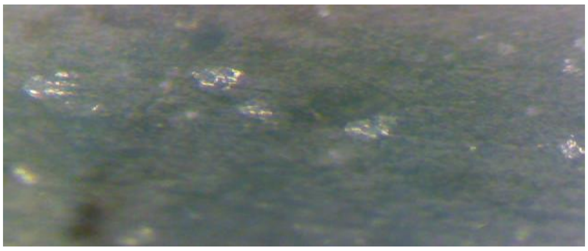
50%KENAF+ 50%FLAX(HYBRID)



90%HYBRID+10%AL



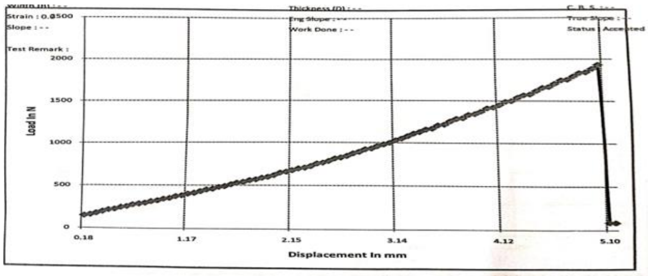
80%HYBRID+20%AL



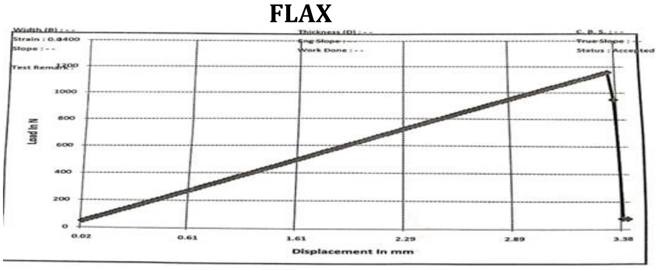
70%HYBRID+30%AL

GRAPHS:

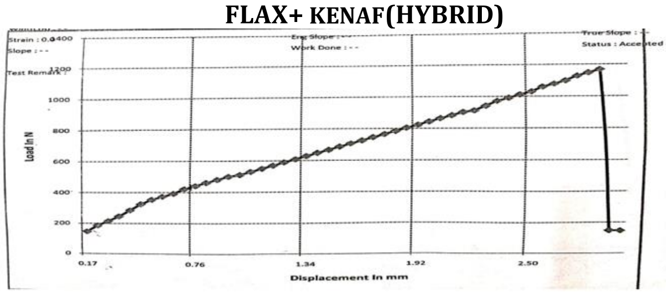
KENAF



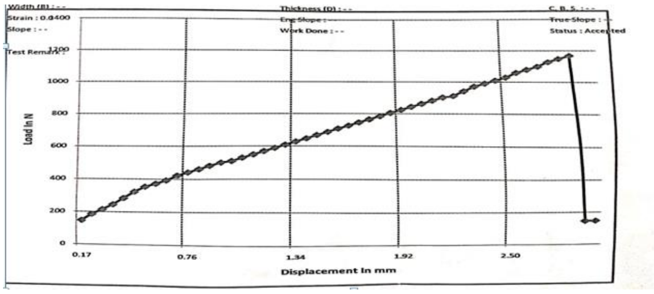
FLAX



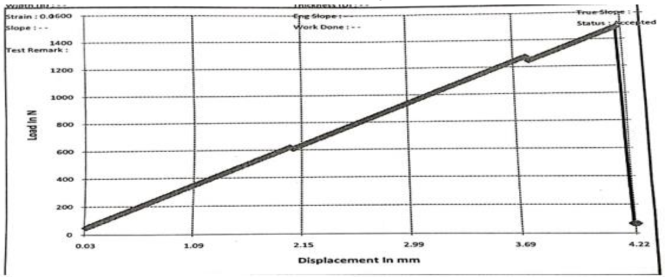
FLAX+ KENAF(HYBRID)



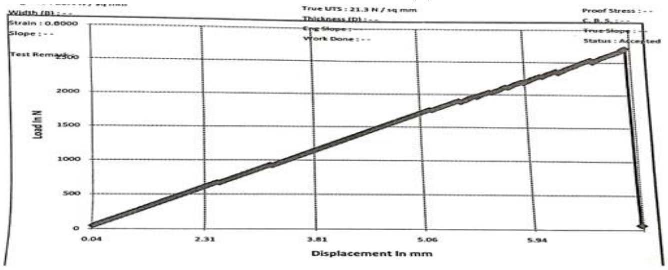
HYBRID+10%AL



HYBRID+20%AL



HYBRID+30%AL



CONCLUSION

- The present work has been done with an objective to explore the use of kenaf fiber, flax fibre and its combinations (hybrid) are used as a reinforcement material in epoxy base, final find out the mechanical properties like tensile,impact,hardness anf grain structure of kenaf fiber, flax fiber and its combination (hybrid) composites. The mechanical behavior of kenaf fiberand flax fiber reinforced hybrid natural fiber composite lead to the following conclusions

- The natural fiber reinforced epoxy hybrid composites are successfully fabricated using hand lay-up technique.

- By increasing the weight percentage of fiber, the mechanical properties also increases up to certain limit. Further, addition causes them to decrease due to poor interfacial bonding between fiber and matrix.

- By increasing length of the fibers we can get more strength.

- By increasing the thickness of specimen we can get better properties than this thickness.

- Due to the low density of proposed natural fibers compared to the synthetic fibers (Glass fibers, carbon fibers, etc...), the composites can be regarded as a useful engineering materials in light weight applications.

- Finally hybride(kenaf+flax) fibre with 30% Al is the concluded this project because good strength and stiffness compared to remaining composites.

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