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A Study on Mechanical Properties Hemp Fiber Based Composites Used In Automotive Side Impact

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***Abstract*—This paper mainly presents the basic mechanical properties experimentally determined of hemp-epoxy reinforced resin specimens and hybrid hemp-glass-epoxy reinforced resin specimens subjected to the tensile loads and impact loads done until it breaks .In present work manufacturing of 4ply, 6ply hemp-epoxy and 5ply hemp-glass-epoxy laminate is done. The Specimens are cut using the shear cutting machine as per the ASTM D3039 standards for tensile tests and ASTM D256 for izod impact tests. Tensile tests are done with different simulation rate such as quasi-satitic(1mm/min),high strain rate(100mm/min, 200mm/min). Young's modulus, tensile strength, maximum loadand other mechanical properties can be experimentally determined using the standard Universal Testing Machine BISS with 100kN load.**

***Index Terms*—hemp fiber, composite laminate, epoxy resin, hybrid, mechanical properties etc.**

I. INTRODUCTION

Composite materials are engineering materials which are proposed to give appreciably higher specific strength and stiffness. It should have more structural efficiency with comparative to earlier existing structured materials. In composites the strength & the stiffness are given by high modulus and high strength reinforcements. Composites offer a high potential for the modified designs with different kinds of matrices and fiber orientations, many more implements, and design of laminate which includes fiber orientation and stacking sequence of individual laminate. Along with this composites have more significant potential to absorb kinetic energy at the time of crash.The advantages of using natural fibers in composite materials are very low cost, having low density, widely available, renewability, biodegradability and recyclability. Some researchers found the uses of natural fibers in building, construction, automotive, and many more applications. For example, vehicle interior parts such as door trim panels which are made from natural fiber-polypropylene (PP) and exterior parts of automotive such as engine and transmission covers made from natural fiber-polyester resins are already in usage.

II. MATERIALS AND THERE PROPERTIES

1. Hemp

In particular the hemp plant yields high quality natural fibers that are low-cost and that shows excellent mechanical properties comparing to other natural fibers. Therefore, they have been used in the automotive industry, mostly probably as interior components. Fig 2.1 shows the bi-directional woven hemp cloth.

Hemp fiber is significant to use in automotive and other applications by having some features

- It is cost effective.
- It has high tensile strength and stiffness.
- It is very effective as replacement of other fibers.
- It reduces molding time.
- It minimizes the weight of finished part.
- It is easy to process and recycle.
- It has consistent quality and availability of supply is possible.

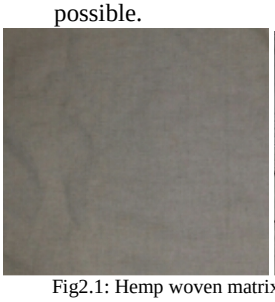

Fig2.1: Hemp woven matrix

Fig2.2: glass-fiber matrix

Table1: Mechanical Properties

PROPERTY	Hemp	Glass fiber	Epoxy
Density (g/cm^3)	1.48	1.9	1.2
TensileStrength (MPa)	690	3400	73
Modulus (GPa)	70	72	5.0
Elongation(%)	1.6	4.9	4.0

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2. Glass fiber

It is also called as fiber glass. That is made up of extremely fine fiber glass. Glass is the oldest, and most familiar, performance fiber. Fiber glass is a lightweight, extremely strong with high strength, and robust material. Though strength properties are slightly lower than carbon fiber and comparatively it is less stiff, the material is usually far less brittle, and the raw materials are less expensive.

Its bulk strength and weight properties made it very favorable, when compared to metals and it can be easily formed using molding processes. Glass fiber is the perfect material when you need to get the advantages of carbon fiber, along with the superior esthetic results. Glass fiber is comparatively is as strong as carbon fiber and does not show through the dentin. Fig.2.2 shows the bidirectional woven glass fiber. Most fabric constructions offer bidirectional glass fiber for more flexibility for layup of complex shapes than the straight unidirectional tapes. Fabrics offer the choice for resin impregnation may be by solution or the hot melt process.

3. EPOXY

Epoxy resin has a property of low viscosity; it is free of solvents and fillers approved for the building of gliders and power-driven aircraft having highest static and dynamic strength.

Applications for epoxy resins include the fields of aerospace, automobile manufacture and shipbuilding, and the tremendously demanding field of high-performance sports tools and equipment's as well as model construction. Processing the resin is suitable for all types of processing methods, such as hand lay-up operations, winding, and press molding (also in vacuum). With high strength bonds metal, wood, plastics, ceramics, etc., can be joined (bonded) without the application of contact pressure. Curing takes place effectively without any shrinkage.

4.Hardener

Hardener EH350 is a low viscosity and fast curing hardener for the use with epoxy resin Araldite 250GY. The care should be taken while mixing the hardener to the resin, the ration of mixing proportion to this hardener is 100:10.

III. CHARACTERIZATION AND TENSILE TEST

First of all, the release gel (wax) is sprayed on to the surface of plate which avoids the sticking of epoxy resin polymer on the surface and which helps to remove the final laminate easily. Thin mylar plastic sheets are placed above and below the laminate to get the better surface finish. On the applied mylar sheet epoxy is spread and bi-woven mats of hemp-fiber is placed on the surface of plate. Then epoxy in semi liquid form is thoroughly mixed in suitable proportion (100:10) with a prescribed hardener (curing agent) and poured onto the surface of hemp mat already placed on the plate. The epoxy is uniformly spread with the help of brush. Next layer of hemp mat is then placed on the polymer surface(figure 3.1).

The process is repeated for each layer of epoxy and fiber to makeup the four ply laminate layer stacked. After placing the plastic sheet, we spray the release gel is on the inner surface of the top surface of plate which is then kept on the stacked layers of 4ply laminate and then it is placed in compression machine, where pressure is applied to remove any air trapped as well as the excess epoxy present. Accordingly to the required thickness metal stacks are kept under the compression machine such that each stack of 1mm is used, for 4ply 2 stacks of 1mm each is kept to maintain 2mm thickness the above head of compression machine is pressed (applied pressure) up to the 2 stacks. Developed composite laminate is taken out and further processed (figure 3.2).

Fig 3.1: Applying epoxy polymer resin with help of brush layer by layer

Fig 3.2: final laminate

Same procedure repeated for 5 ply hybrid and 6 ply composite.Volume fraction can be calculated using the relation,Volume fraction = vol of fiber/(vol of fiber +vol of matrix)

V.F = (mf x em)/[(mf x em)+(mm x ef)] [7]

The laminate is further processed and this laminate is cut accordingly the ASTM D3039 standards[8]. Fig 3.2 shows the samples of hemp-epoxy and hybrid hemp-glass-epoxy before tensile testing.

Fig 3.2.Hemp-epoxy samples before tensile testing

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The samples are tested in the universal testing machine BISS with loading of 100kN load shown in fig 3.3

Fig 3.3.universal testing machine

Fig 3.4 shows the samples after tensile testingsimultaneously the results are noted.

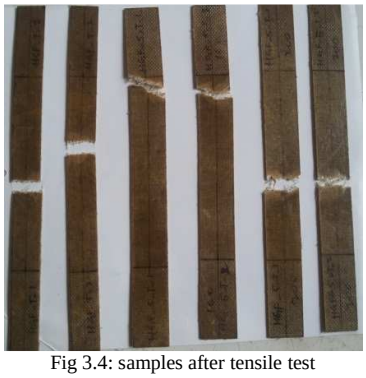

Fig 3.4: samples after tensile test

IV.TENSILE TEST RESULTS

The maximum best results obtained by the tensile results are represented in below table 2.

TABLE 2: mechanical properties with simulation rate of 200mm/min

Material/ properties	Hemp-Epoxy (4 ply)	Hemp-Epoxy (6 ply)	Hybrid (5 ply)
Young's modulus "E"(MPa)	4130	1620	5059
Density "ρ"(Kg/m^3)	1200	1480	1630
Peak stress(MPa)	29.84	22.61	113.33
Yielding stress (MPa)	22.424	13.36	66.05
Tangent modulus(MPa)	79.53	211.96	2747.5
Failure load (KN)	1.53	1.70	4.36

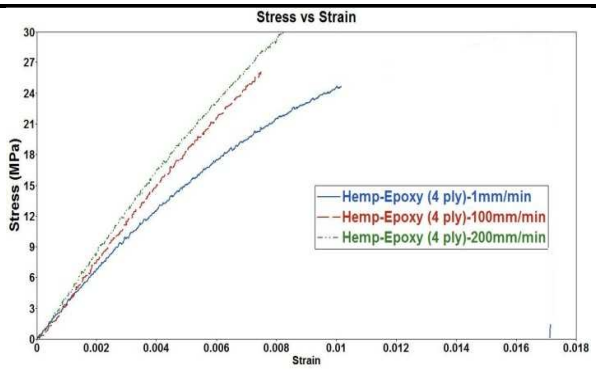

Fig 4.1: Stress strain curve for 4ply hemp epoxy

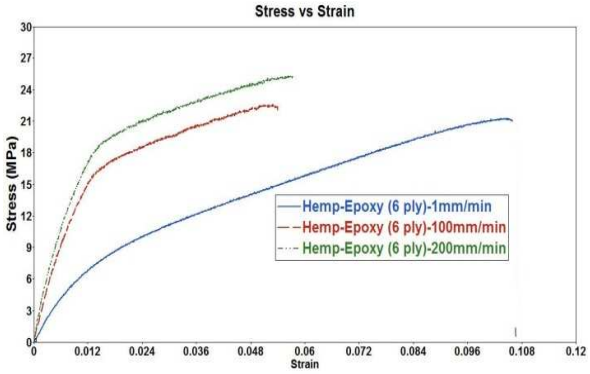

Fig 4.2: Stress strain curve for 6ply hemp epoxy

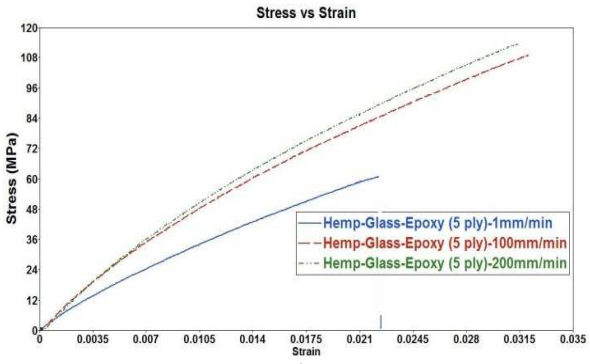

Fig 4.3: Stress strain curve for 5ply hemp-glass-epoxy

It is noted from fig 4.1 that with increase in the rate of loading the strength has increased.The peak strength increased from 24.5MPa to 30MPa with the loading rate increase from 1mm/min to 200mm/min.

It is noted from fig 4.2 that with increase in the rate of loading the strength has increased.The peak strength increased from 21.2MPa to 23MPa with the loading rate increase from 1mm/min to 200mm/min.

It is noted from fig 4.3 that with increase in the rate of loading the strength has increased.The peak strength increased from 60.8MPa to 113MPa with the loading rate increase from 1mm/min to 200mm/min.With the addition of glass fiber the strength of the laminate increased tremendously.

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V. IZOD IMPACT TEST

Standard impact testing machine is as shown in below fig 5.1. In the experimental setup, an arm which is held at a specific height (constant potential energy) is made to release such that this released arm hits the sample which is placed at specimen holder at bottom. There are two possibilities the specimen breakout or else the weight rests on specimen. The impact energy can be identified from the point of energy absorption by the sample. A notched specimen is used for the determination of impact energy and notch sensitivity.

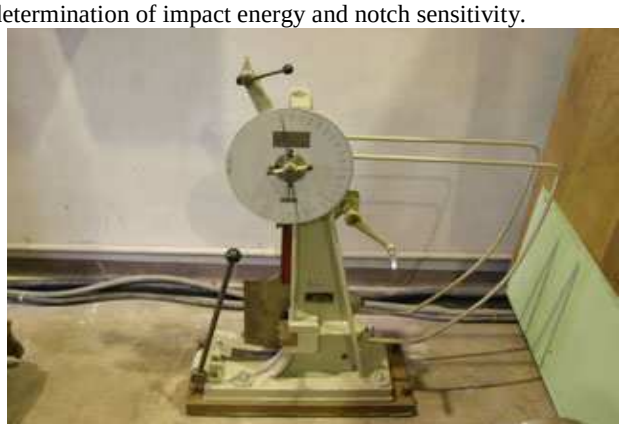

Fig 5.1:Izod Impact testing machine

All the specimens are notched as per directed from the standards. As per the standard ASTM D256 specimen are placed in the holder half beneath the v notch angle 450 and the arm is released and the impact energy is noted down[9].
The izod impact test data results obtained for each specimen conducted in impact testing machine are tabulated in the below table 3.

Table 3: Izod Impact Test Data

Material/ properties	**Hemp-Epoxy (4 ply)**	**Hemp-Epoxy (6 ply)**	**Hybrid (5 ply)**
DEPTH UNDER NOTCH	3.12	3.22	3.08
BRAKING ENERGY(JOULE)	1.922	2.82	1.425
IZOD IMPACT (JOULE/MIN)	906.12	861.32	712.53

VI. DISCUSIONS

In this Present work tensile test and izod test has been done on particular specimens of 4-ply, 6-ply of hemp epoxy and 5-ply hybrid of hemp glass epoxy composite. Tensile test was carried out with quasi-static (1mm/min) and high strain rate (100,200mm/min rate) in BISS UTM Machine OF 100 KN. Izod test was also done on same specimens under impact machine. Results of tensile tests are shown in above table 2, izod results shown in table 3.

By studying all the test results it is observed that the test results were good on 5-ply hybrid (hemp glass epoxy) composite. 5-ply hybrid comparatively gives better peak stress (up to 113MPa), yielding stress (up to 66MPa) and peak load (up to 5KN) which is better to use in automotive.

VII.CONCLUSIONS AND FUTURE WORK

The experiments are carried out to determine tensile and impact properties of Hemp-Epoxy and Hemp-Glass-Fiber based composites for bi-woven mat.

Hemp-epoxy with combination of glass fiber gives more tensile strength, yield stresses and impact strength comparing with only Hemp-Epoxy composites.

Tensile and impact strength is observed to be maximum by the use of bi-directional woven mat i.e. at 90^0 orientations, it is observed that tensile and impact energy is maximum.

Future work

Due the lesser weight and more tensile strength and energy these composites can be used in applications of automotiveindustry

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