

Studies on mechanical strengths of hemp-glass fibre reinforced epoxy composites

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Abstract. The objective of this study is to produce hemp and glass fiber incorporated composites with epoxy resin polymer matrix and to determine the mechanical strengths like, impact strength, tensile strength and flexural strength of the different samples. The hemp and glass fibres reinforced composite material components and products plays a major role in the field of automobile and construction sectors. By using hand layup process the different composite samples are fabricated as per the ASTM standards and the specimens were tested with aid of UTM tensile testing machine and charpy impact energy testing machine. The experimental reading of tested samples indicates that the untreated hemp and glass fibres composite exhibit the excellent tensile and flexural strengths. From the tested samples the SEM analysis was carried out to study the morphological properties

Keywords: Hemp fibre, Glass fibre, Hand layup process, Mechanical testing, Morphological analysis.

1. Introduction

The part of increasing environmental awareness and interests in the use of lignocelluloses natural plant fibers for incorporating composite materials have been received potential attention in the production of automotive components. The natural plant fibers have superior strengths such as less price, less density, high strength, , less abrasiveness, easy availability, recyclability, permeability, thermal insulation, acoustic insulation, biodegradability and renewability, no irritation to the human skin, less wastages and less energy consumption [1-5]. Most of the plant fibres like hemp, flax, sisal and kenaf are presently receiving more research attention by reinforcing in composite materials for the replacement of synthetic fibres composites. Hemp fibres are cellulose enriched fibre than other fibre because the hemp plant bast fibres are very long and performs with more strength. In general the uni-directional, bi-directional and randomly oriented hemp fibre reinforced composite parts like, Interior door panel, Body panel, Interior storage bins, Underbody panel, Luggage compartment, shelf, Spare



tire cover floor mats and Cargo floor tray are fabricated in most of the automobile vehicles [7]. Shahzad conducted a review studies on physical and mechanical properties of different untreated hemp fibres incorporated composites with polyester, polypropylene and biodegradable matrix materials. The hemp plant fibres hold the sufficient strengths that would replace the synthetic fibre incorporations in composites. The wide research works has been performed on the incorporation of bio based thermoplastic and thermoset resins in hemp fibre composite materials. The surface treatments of different fibres have been found that the improved mechanical strengths, good interfacial bonding between fibres and polymer matrices and less water absorption characteristics [8]. Baghaei et al. [9] fabricated the unidirectional hemp fibre polylactic acid composites with 30 weight percentage of hemp fibres and studied the mechanical properties and thermal behaviors. The different fibre orientations like, random, aligned and linear has been used to fabricate the composites. The aligned fibre orientation composite samples exhibit the superior mechanical strengths than other fibre orientation composites. Mostefai et al. [10] has been investigated the effect on mechanical strengths and microstructures of composite materials while hybridizing the plant hemp fibres with modified and unmodified mortar. The obtained results indicates that the improved mechanical strengths with progressively low stiffness of hemp fibre composites. The hemp fibre/PP composite materials with and without maleic anhydride grafted polypropylene coupling agents has been produced using injection molding process. The interfacial characteristics of fibres, visco-elastic behavior, static mechanical and dynamic mechanical characteristics of hemp fibre incorporated polypropylene composite materials were analyzed under the controlled temperature of 25°C to 150°C. Also studied the effect of influence of different volume content of hemp fibres with MAPP coupling agents in the composites [11]. Chaudhary et al. fabricated the different natural fibre incorporated epoxy composite materials using jute, hemp and flax fibres followed by the jute-hemp-epoxy, hemp-flax-epoxy, and jute-hemp-flax-epoxy hybrid composite laminates were fabricated using hand lay process. The mechanical strengths including hardness behavior of these composites were performed using universal tensile testing machine, impact and hardness testing machine. The observed results of hemp-flax-epoxy hybrid composite samples exhibits the excellent tensile property of 58.59 MPa and impact energy of 10.19KJ/m² than other hybrid epoxy composites. Similarly Jute-hemp-epoxy hybrid epoxy composite samples hold the high flexural property of 86.60MPa than other hybrid epoxy composites [12]. M A A Ahmad et al. fabricated the hemp fibre-Polyethylene Terephthalate hybrid composites samples as per ASTM D638 and investigated the tensile strengths of various samples. By using the Vacuum moulding method the hybrid laminates were fabricated with interwoven and neat woven hemp fibres. The experimental results showed that the tensile property of bi-directional hemp fibre were improved by 8% than that of neat woven hemp fibre composite laminate samples [20].

2. Experimental Process

2.1. Materials

For this experimental work the hemp/glass fibre incorporated composite plates were manufactured by hand lay-up method. The raw hemp fibres are procured from M/s. Go green products Ltd., Chennai. The other matrices like, epoxy resin (Grade: 758), hardener (Grade: HY911), accelerators and waxes are procured from the M/s. Sakthi glass fibres Ltd., Tamilnadu, India. The chemical constituents, physical properties and mechanical properties of hemp fibre, glass fibre and epoxy resins are reported by various researchers are listed in the following Tables 1 and 2.

Table 1. Chemical properties of hemp [1, 6, 7, 8, 13-17]

Chemical properties	Hemp fiber
Cellulose (wt%)	68–77
Hemicelluloses (wt%)	7–22.4
Lignin (wt%)	2–10
Micro-fibrillar angle (deg)	2–6.2
Moisture content (wt%)	6.2–12
Pectin (wt %)	1-25
Biomass (Mg DM/ha/y)	7–34.0

Table 2. Physical properties of hemp fibres, glass fibres and epoxy resin [1, 7, 8, 10, 15-17]

Physical properties	Hemp fiber	Glass fiber	Epoxy resin
Density (g/cm ³)	1.4–1.6	2.50-2.60	1.1–1.3
Tensile Strength(MPa)	200–1040	1956	55–130
Stiffness (GPa)	17.6-66	79	2.7–4.1
Tensile modulus (GPa)	23.5–90	2000-3500	--
Specific tensile strength (MPa)	210–510	--	--
Young's modulus (GPa)	30–60	70-80	--
Specific Young's modulus (GPa × cm ³ /g)	20–41	27-32	--
Diameter(μm)	270–900	--	--
Length (mm)	8.3–14	--	--
Aspect ratio (length / diameter)	549	--	--
Percentage of elongation (%)	1–3.5	--	--
Failure strain (%)	2-5	2.5	--

2.2. Preparation of hybrid composites

The top surfaces of the base plates were cleaned by applying thinner chemical after removing the dust and burns on the surfaces by scrubbing with aid of an emery sheet. The wax coating was given on the surfaces of base plate after cleaning, and then the coated plates were kept under ambient conditions for 15 minutes for hand lay-up process [1]. The matrices were prepared by mixing the epoxy resin and hardener with the ration of 10:1 and uniform mixing was done with regular interval of time period. The pot life of these matrices was identified as 30 minutes based on the standard laboratory readings given in the chart. At the initial stage, hemp fibres were kept under sun light for 8 hours to remove the moisture content presents in the fibres. The composite laminates were fabricated by applying the matrices between the glass and hemp fibres with constant weight. Each laminate consists the five layers of hemp and glass fibre by hand lay-up process. The glass fibre mat was used on the top and bottom layers of these composite laminates. The dimensions of the fabricated composite laminates were restricted as 275 x 275 x 5 mm. Then the fabricated laminates were dried under room temperature with aid of the compressive load for one day. The following figures 1 and 2 are shows the fabrication process of composite laminate with raw hemp plant fibre and glass fibre [18-19].



Figure 1. Raw hemp fibre



Figure 2. Processing of Hemp/Glass fibre

2.3. Mechanical strengths of Composites

2.3.1. Tensile testing

From the fabricated composite plates, three different tensile test samples were prepared as per the standard ASTM D638. There are three specimen were used from each laminates for testing the tensile behavior of composite plates. The tensile test has been conducted on the digital UTM machine, by applying equal and opposite pull load on the prepared samples until to get fracture and the corresponding readings are noted. The same methodologies were applied for remaining samples which produced in the same composite plates to get the ranges of tensile strength for comparison of tensile results.

2.3.2. Flexural testing

From the fabricated composite plates, three different flexural test samples were prepared as per the standard ASTM D790. The three flexural test samples of each composite plates of hemp/glass fiber incorporated epoxy composites were cut with the help of hacksaw. The prepared flexural test samples were tested by applying three point bending load with aid of digital UTM machine. The test results of flexural modulus and corresponding displacement of each sample were observed and listed for comparison of results.

2.3.3. Impact testing

From the fabricated composite plates, three different impact test samples were prepared as per the standard ASTM A370 and the sides of the samples are finished by emery sheets and “v” shape notches were cut on any one long edges with the help of hacksaw. The three impact test samples were prepared from hemp/glass fiber incorporated composite plates for examining the impact energy absorbing capacity during its failure. These prepared samples were tested by means of charpy testing machine and the energy stored to break the samples were observed for result analysis and comparison.

3. Results and discussion

In this experiment, the hemp fibers were incorporated with glass fibers and different composite plates were fabricated to conduct the mechanical properties. After that the test samples were prepared as per ASTM standards with required finishing from the fabricated composite plates. Then the mechanical testing of composites like tensile, flexural and impact test has been conducted with aid of digital UTM machine and impact test machine. The mechanical test results of different tested samples were listed in Table 3.

Table 3. Test results of hemp/epoxy samples

hemp-glass fiber composites	Tensile strength (MPa)	Flexural strength (KN)	Impact strength (Joules)
Sample 1	37.52	0.27	5.32
Sample 2	38.47	0.29	4.99
Sample 3	35.51	0.22	5.83

3.1. Tensile strength analysis

The samples prepared as per standard from the composite plates were tested by digital UTM machine and the generated graph between force and displacement has been obtained directly from the machine by applying pull load. The tensile test readings of different samples were presented in Table 3. From the observed tensile test readings of hemp/glass fibres composite samples shows the better tensile property it varies from 35.51MPa to 38.47 MPa. These composite components are suitable for structural applications in home appliance furniture's and interior parts of automobile vehicles.

3.2. Flexural Strength analysis

The flexural strength of the hemp/glass fibres incorporated composite samples was tested by applying bending load and the generated graph between force and displacement has been obtained directly from the machine. The flexural readings of different samples were presented in the Table 3. The observed flexural test reading of hemp/glass fibres composite samples shows the nominal flexural property and it varies from 0.22KN to 0.29 KN.

3.3. Impact strength analysis

The impact test was conducted for examining the impact energy/load withstanding capability of the hemp/glass fibres composite samples and the charpy test method was used in this experimental investigation. The energy absorbed to break the “v” notched composite samples during impact testing

were presented in the Table.3. The impact results of tested samples exhibits nominal impact strength which suitable to holds the less impact load on automobile structural components and it varies from 4.99 Joules to 5.83 Joules.

3.4. Morphological analysis

The gold coating was done on the surfaces of the prepared samples in order to increase the conductivity of the tested polymeric samples [12]. By using the scanning electron microscope, failure morphology of the hemp/glass fibres tested composite samples were examined. The SEM images of the hemp/glass fibres composite samples subjected to tensile, flexural and impact loading were showed in Figure 3. From the SEM images, it can able to see that the voids in matrices, matrix failure, fibre dislocations, edge failure of hemp fibre and fibre pullouts were clearly observed and indicated in the following SEM micrographs[18-19].

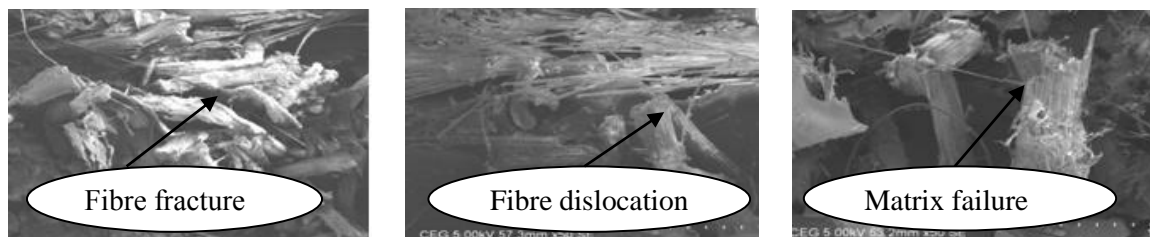


Figure 3. Morphological characteristics of hemp/glass fibre test samples.

4. Conclusion

Now days, the researchers focusing their research work in the field of composite materials to fabricate the ecological based natural composites without compromising to replace the man-made material components or traditional material components in the field of automobile sectors. The hemp/glass fiber incorporated composites were fabricated and the tensile property, flexural property and impact property of these composite samples were noted and analysed. Based on the observed mechanical readings the following conclusions are made for this experimental studies.

- The hemp/glass fibers composite samples withstand the maximum tensile property which holds the maximum value of 38.47MPa. Similarly the flexural strength of 0.29KN was observed.
- The maximum impact energy of the composite samples varies from 4.99Joules to 5.83Joules.
- The morphological studies were carried out by using the tested samples under different loading conditions with aid of scanning electron microscope. The interfacial behavior, internal bondings of failure surfaces, matrices void, and fiber pull out from the matrix materials and fiber fractures were clearly studied.
- It is suggested that the hemp/glass fibers incorporated epoxy composite materials can be replace the man-made/synthetic fiber incorporated composite materials.

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