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Investigation on Flax Natural Fiber Reinforced Polymer Matrix Composites

K G Prakash [1]
Assistant Professor,
Department of Mechanical Engineering,
RYMEC, Bellary, Karnataka, India

Swamy N [2]
Assistant Professor
Department of Mechanical Engineering,
RYMEC, Bellary, Karnataka, India

Manjunath K B [3]
Assistant Professor
Department of Mechanical Engineering
RYMEC, Bellary, Karnataka, India

B G Chandru [4]
Assistant Professor
Department of Mechanical Engineering,
RYMEC, Bellary, Karnataka, India

***Abstract* — The Natural fiber-reinforced polymer composite is booming in the fields of industries and engineering applications. This paper presents an experimental investigation on the mechanical properties for Flax natural polymer reinforced composites. The raw material used in the present work is long flax fiber. The epoxy resin and hardener are mixed according to the weight ratio. The tests were carried out as per ASTM standards and newly developed composites are characterized for their mechanical properties. Experiments like tensile test, impact test, hardness test, chemical test, and water absorption test were conducted and it was observed that the NPMC has got good properties. The natural fibers present many advantages as compared to synthetic fibers which make them attractive as reinforcement in composite materials.**

Keywords — *Natural fibers, Epoxy resin, Mechanical properties, Chemical properties.*

1. INTRODUCTION

Composites are fiber-reinforced plastics used in a variety of applications and industries. Natural fiber is a renewable sources and a new generation of reinforcements and supplements for polymer based materials.

The natural fiber composite materials are environmental friendly composites and have been a proved as green composites due to the increasing environmental awareness. Natural fibers are material which replaces the synthetic materials and its related products for the less weight and high energy conservation.

Automotive and aircrafts industries have been actively developing different kinds of natural fibers, mainly on hemp, flax, and sisal and bio resins systems for their interior components. Good properties with lower prices of natural fiber composites are making it more attraction for various applications.

Flax (linseed), with the binomial name Linum usitatissimum is a member of the genus Linum in the family Linaceae, which has been grown throughout the world for millennia is the source of products for existing, high-value markets in the textile, composites, paper/pulp and industrial/ nutritional oil sectors Flax fiber is extracted from the bast of the stem of the flax plant.

Flax is the source of industrial fibers and as currently processed, results in long line and short fibers. The application of good grades is used for linen fabrics such as damasks, lace, and sheeting. Normal grades are used for the manufacturing of twine and rope and for the canvas and webbing equipment.

1.1 Natural Fiber Reinforced Composites

The interest in natural fiber-reinforced polymer composite materials is rapidly showing good pickup both in terms of their industrial applications and engineering research. Plants such as flax, cotton, hemp, jute, sisal, kenaf, pineapple, ramie, bamboo, banana, etc., as well as wood, used from time immemorial as a source of lignocelluloses fibers, are more and more often applied as the reinforcement of composites. Their good mechanical properties make them an attractive ecological alternative to glass, carbon and man-made fibers used for the manufacturing of composites. The natural composites are more environmental friendly, and are used in transportation, military applications, building, and construction industries, packaging, consumer products, etc.

2. EXPERIMENTAL WORK

This part of content covers the materials used in the work, their properties and method of composite fabrication and ends with, how Specimen is prepared out of laminates and Experimentation carried-out. The present works with following materials have been intended to use due to their advantages and applications.

2.1 Materials

The materials used for this work are shown in Table. The almost all applications these materials are using because of the fiber itself are regarded as an isotropic material.

Table 2.1 Materials used for fabrication

SL.NO	REINFORCED MATERIAL	MATRIX MATERIAL
1.	Flax fibers	L-12, LEPOX, K-6, HARDENER.

2.1.1 Reinforcement Material

Fig 2.1: Flax fibers

2.1.2. Epoxy

In this work L-12 Lapox is used as a matrix material for the bonding of composites. K6 is the hardener. A substance or mixture added to a plastic composition to take part in and promote the curing work, also a substance added to control the hardness of the cured film.

3. HAND LAY-UP/WET LAY-UP

In this work, Hand Lay-Up method of fabricating the composites was applied as the method was cheap, and can be comfortabilly made with available materials. Before giong to start lamination process, the required nunber of reinforcement layer is cut according to calculation. during this time the calculated quantity of Epoxy and Hardner are measured using a measuring jar and poured into a beaker soon after pouring hardener into Epoxy, the mixture is kept stirring, till the completion of lamination using a glass rod. But in the present work along with reinforced composites, were also fabricated. For fabricating the composite, the procedure is to follow by calculating the quantity of Epoxy and flax fibers layers, using the law of consistency of volume. The measured quantity of epoxy is poured in a beaker, and then the hardener is added to the epoxy, and the mixture is stirred well. This mixture is used for lamination.

3.1. Specimen Preparation

The specimens were fabricated as per ASTM standards. The test specimen along with specimen dimension and standards for different tests are discussed below.

Flax fiber composite was fabricated by hand lay-up technique in a mould at room temperature. The matrix material used was LAPOX L-12 and a room temperature curing polyamine hardener (K-6). This matrix was chosen, because it has good resistance and good adhesive properties. The experimentation on the specimen was carried out according to the ASTM standards. The following tests have been experimented.

3.1.1. Tensile Test

The specimen was fabricated for the weight fractions for 50% of matrix and 50% of flax fibers for the hybridization the tensile strength was determined by tension test as per ASTM D3039. The damage characterization has been mainly focused on the evaluation of characteristics of tensile load and the volume fraction of resin was kept constant. The specimen was loaded in tension. The specimen is prepared for 25 mm wide and 250 mm long and thickness of 3 mm with the two specimens were tested and Average result is obtained. The tensile test specimen drawing is shown in Fig.

Fig 3.1: Tensile test specimen.

3.1.2 Impact Test

A. Charpy Impact Test Specimens as Per ASTM Standards

When the striker impacts the specimen, the specimen will absorb energy and get yields. At this point, the specimen will begin to undergo plastic deformation at the notch. The test specimen continues to absorb energy and hardens at the plastic zone at the notch of the specimen. When the specimen stops to absorb energy the fracture occurs.

B. Specimen description

Charpy test specimens normally measure 55x10x10mm The notches are as follows:

- V-notch – A V-shaped notch, 2mm deep, with 45° angle and 0.25mm radius along the base.
- U-notch – A U-shaped notch, 5mm deep, with 2mm U notch along the base.

C. Rockwell Hardness Test

The Rockwell test is a hardness test based on indentation hardness of material. The Rockwell test finds the hardness by measuring the depth of penetration of an indenter under a load compared to the penetration made by a preload.

D. Brinell Hardness Test

The oldest hardness test methods in common use today, the Brinell test and are frequently used to find the hardness of forgings and castings. There-fore, Brinell tests are done on large parts. By varying the test load and size of the ball, nearly all metals can be tested using a Brinell test.

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E. Operation

The determination of the Rockwell hardness and Brinell hardness test of a material involves the application of a minor load followed by a major load, and depth of penetration, hardness value measured directly from a dial, in which a harder material gives a higher number. The main advantage of Rockwell hardness is its ability to display hardness values directly and thus obviating tedious calculations made in other hardness measurement techniques. In order to get a reliable reading the thickness of the test the specimen should be at least 8-10 times the depth of the indentation. Also, readings should be taken from a flat perpendicular to the surface, because convex surfaces give lower readings with correction factor. A correction factor can be used if the hardness of a convex surface is to be measured.

F. Chemical Tests

The fabricated composite is treated with acid & base like hydrochloric acid, sulfuric acid and mineral water. For this the specimen is cut for small dimension of 25x25 mm. The materials are kept in this solution for 6 days. The weight is measured before treating with the chemicals and repeatedly then the values are noted.

4. RESULTS AND DISCUSSION

In this study, the tensile, impact test and hardness test were carried out on flax fiber composites to study the effect of various mechanical and chemical properties. In this section experimental result obtained for tensile, impact and hardness tests are widely discussed. The results were analyzed by plotting graphs and tabulating tables for specimens prepared.

4.1 Effect of Load versus Displacement

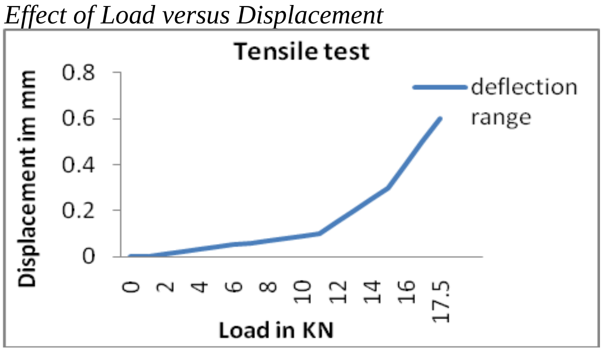

Fig.4.1: Effect of load versus displacement

From the above graph it is found that when the load is applied the deformation talks place slowly up to certain extent and it goes on increases more in displacement as the load increases after crossing the 0.1 mm displacement the higher displacement taken place near to the breaking point. From this the conclusion is the material is of brittle range applications and used in many application where the brittle nature is required.

4.1.1 Tensile specimen

Specimen before testing

Specimen after testing

SPECIMEN

Fig 4.2: Tensile test specimens for testing

4.2 Impact Test: Impact strength is obtained by dividing the energy absorbed (kg-m) by the cross sectional area of the specimen under the crack tip.

Table 4.1: Results of Impact Test

Sl .no	Type of notch	Impact Energy (joules)	Impact Strength (joules/sq.mm)
1		1.9	1.95
2	U-notch	1.92	2.05
3		1.93	2.08
AVG		1.92	2.0267
1		1.34	3.68
2	V-notch	1.39	3.968
3		1.36	3.824
AVG		1.363	3.824

U-NOTCH SPECIMEN

V-NOTCH SPECIMEN

Fig 4.3 Impact testing specimens

4.3 Rockwell Hardness Test

The Rockwell hardness test method consists of test material with a diamond cone or hardened steel ball indenter. The indenter is made to force into the test material under a minor load usually 10 kgf. When the equilibrium has been reached, the additional major load is removed but the preliminary minor load is still maintained. Removal of the additional major load makes a small recovery, so reducing the depth of penetration. The increase in depth of penetration, resulting from the application and removal of the additional major load is calculated as the Rockwell hardness number.

Table 4.2: Results of Rockwell Hardness Test

Sl. No	Type of Specimen	Rockwell Scale			Rockwell Hardness No	Average
1	Flax Fibers	L	60	1/4" Ball	93	94.33
2	Flax Fibers				94	
3	Flax Fibers				96	
4	Flax Fibers	B	100	1/16" Ball	74	75.60
5	Flax Fibers				75	
6	Flax Fibers				78	

4.4 Brinell Hardness Test

The Brinell hardness test method consists of indenting the test material with a 8-10 mm diameter hardened steel or carbide ball subjected to a load of 3000 kg. For softer materials the load can be reduced to 1500 kg or 500 kg to avoid more indentation. The full load is normally applied for 10 to 20 seconds in the case of iron and steel and for at least 30 seconds in the case of other metals. The diameter of the indentation left in the test material is measured with a lower microscope. The Brinell hardness number is calculated by dividing the load applied by the surface area of the indentation.

TABLE 4.3: Results of Brinell hardness Test

Sl. No	Type of Specimen	Major load (kg)	Dia of steel ball (D) mm	Dia of indenter (d) mm	BHN kg/mm^2	Average
1	Flax fabric	187.5	2.5	2	47.44	54.79
2	Flax fabric	187.5	2.5	1.8	62.40	
3	Flax fabric	187.5	2.5	1.9	54.55	

4.5 Results of Chemical Tests: (Weight in grams)

TABLE 4.3: Chemical Test and Water Absorption Test

Chemical	Weight of specimen before test (gms)	Weight of specimen after 24 hours (gms)	Weight of specimen after a week (gms)
H_2SO_4	2.26	2.68	2.75
HCL	2.8	2.82	2.9
H_2O	2.31	2.71	2.76

Fig. 4.4: Chemical testing specimen

5. CONCLUSION

In this paper an attempt was made to determine the tensile, impact and chemical properties of flax fiber reinforced composite. Tests were conducted on three specimens for each type of composite & the average was considered for the value. The following observations were made

- The strength of the composites may increase still as the fiber volume increased
- The impact, hardness chemical test also gives the good conditioning properties for the application.

6. SCOPE OF FURTHER WORK

We can vary in both the matrix and fibers for the betterment of good results as compared to the work and also can add the filler material for the weight reduction purpose for the condition of high strength to weight ratio purpose.

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