Experimental Evaluation of Mechanical Properties of Hybrid Composites

Sai Krishna Adurthi[1], S. Sanyasi Naidu [2]

[1]*Mechanical Department, Student at MVGR College, Vizianagaram*
[2]*Mechanical Department, Professor at MVGR College, Vizianagaram*

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Abstract - : *This century has seen remarkable accomplishments in green innovation in material science through the improvement of natural and metal fiber-reinforced composites. The improvement of superior engineering products made from natural resources increasing day by day. Natural fibers are considered one of the environmentally friendly materials such as i.e. (Hemp, Sisal, Flax). Which have good properties compared to plastics and also low cost with low density, these are also biodegradable. This paper explores an overview of natural fiber and metal laminated reinforced composites. Mechanical behaviors according to their composition were discussed. Mechanical properties have been determined by performing different tests such as Hardness, Tensile, Volatile analysis, Stress analysis, density analysis on specified machines which are clearly discussed in this paper. This paper also gives brief information about several methods used in the manufacturing of natural and metal fiber-reinforced composites. The properties of materials have also been discussed.*

***Key Words*: Natural fiber composites, Hybrid Composites, Hardness test, Tensile test, Volatile and Density analysis.**

1. INTRODUCTION

A composite material is made by combining of two or more simple materials. These composite materials give different and unique properties. In composite materials, there are two phases which are matrix and reinforcement[1]. These segments have significantly different mechanical properties the matrix is softer it serves as a filler material to achieve stability of the hard phase. The reinforcement is a solid and hard component. The research towards the development of new reinforced composites with natural fibres will be increased gradually due to the advantages like low cost, light weight, non-abrasive nature, and moderate strength which gives certain advantages to use these new classes of bio composites in various application like automotive, aerospace and construction industry[2][3]. In recent years, a significant amount of interest has been shown in the potential use of natural fibres to replace glass fibres in composites. Although these fibres are not as strong as synthetic fibres, these are cost effective and biodegradable. In this research work, two types of natural fibres such as hemp, flax and sisal fibre are used as reinforcement along with aluminium metal[4][5]. These three natural fibres are rich in cellulose and due to this reason, these fibres have high fibre orientation and to evaluate the mechanical and machining characteristics of the composites[6][9]. The required natural fibres are collected and the resin say the epoxy resin I used the hand layup techniques is used to make the natural fibre sheet to be stacked one over the other with the epoxy ren and the curing and it is made into the required composite sheets[8]. The required test like tensile, hardness, volatile test analysis are done.

Chand et al. [10] reported the effects of testing speed and gauge length on the mechanical properties of other kinds of natural fibres (sun-hemp fibres). Their results support the magnitudes are much lower than those of sisal fibres. (For example, when the gauge length is 50 mm and testing speed is 50 mm/min, the tensile strength of sisal fibre is 759 MPa. However, for sun-hemp fibre, the tensile strength is only 283 MPa. The mechanical properties of sisal fibres obtained from different age at three different temperature were investigated by Hashmi [11]. The tensile strength, modulus and toughness (defined as energy absorption per unit volume) values of sisal fibre decrease with increasing temperature. The relative effect of plant age on these mechanical properties is less prominent at 100 °C than at 30°C.

Yang et al. [12] studied the relationship of surface modification and tensile properties of sisal fibres. The Thermal treatment (at 150°C for 4 h) seems to be the most desirable method in terms of strength and modulus properties because of the increased crystallinity (from 62.4% for untreated to 66.2% for 150C/4 h treated) of sisal fibres. To improve the moisture-resistance, Verma s et al. acetylated sisal fibre and studied its tensile strength [13]. It was shown that acetylation could reduce the moisture content from 11 to 5.45%. However, the tensile strength of acetylated sisal fibre was reduced from 445 to 320 MPa caused by the loss of the hemi-cellulose in the fibre during acetylation.

1.1 Experimental procedure: the experiment procedure starts as follows.

1.2 Selection and cutting of materials

In this present investigation, I have used fibers and aluminum metal sheet for fabricating the reinforced composite specimen figure 2.1 represents different natural fibers used for the reinforcement of composite material and these are flax, hemp, sisal and aluminum metal sheet. I have used Epoxy resin (LY 556) and Epoxy hardener (HY 951) mixed in 1:10 ratio respectively for 15 to 20 minutes using a stirrer. Complete mixing of epoxy and hardener gives better binding capacity .

(A) Flax fiber mat

(B) Hemp fiber mat

(C) Sisal fiber mat

(D) Aluminum metal sheet

Figure 1 Natural fibers and aluminum metal sheet

1.3 Resign preparation:

Dinesh and Jagadish [3] has used the following resign to make the reinforced composite material. To prepare the resign we must Mix LY 556 epoxy, HY 951 hardener in 1:10 ratio for 15 to 20 minutes using a stirrer. Complete mixing of epoxy and hardener results in better binding capacity to the resin. Incomplete mixing of composition leads to formation of air bubbles.

1.4 Fabrication of reinforced composite:

1. Application of single layered resin on thin laminated cover [Provide better surface finish].
2. Placing of fibers on thin resin coat in layer wise without any Breakage of fiber at middle
3. Placing the aluminum metal sheet among fibers in layer wise without any Breakage of fiber at middle
4. Apply resin on the fibers using a brush and make sure resin Apply the resign to every single fiber. This gives strength to the fiber.
5. Close the fibers using another laminated sheet
6. Removing air bubbles by applying pressure Using a roller having smooth surface finish

1.5 Curing of test specimen:

After fabrication test specimens should be cured for some time so that the resign binding will be stronger. The specimen will also get stronger. The life of the specimen depends on the curing time.

Figure 2 Test specimens left for curing.

1.6 Cutting of test specimen:

After curing reinforced composite for hours we need to cut it into required dimensions.

2. Method of testing

2.1 Hardness testing method:

Standard test method, ASTM D785 [18], used to test the unidirectional composite specimens. The composite materials used are natural fiber and unsaturated polyester resin. The specimen prepared by hand layup process in the form of a square strip of 100*100*6 mm thick dimensions. The gauge length, thickness and width are measured with 0.001 mm least count digital micrometer. The specimen is placed on the Rockwell hardness test equipment, load is applied on it and readings are noted.

Figure 3 Hardness test machine

- First, the indenter pressed with the test pre-force on a specimen to a penetration depth of h0, defines the reference level (basis) for subsequent measurement of the residual indentation depth (h).

- Next, the additional test force applied for a dwell period defined in accordance with the standard (several seconds), whereby the indenter penetrates into the specimen to a maximum indentation depth of h1. The test pre-force plus the additional test force gives the total test force (also referred to as total force or main load).

- After the dwell period, the additional test force removed; the indenter moves up by the elastic proportion of the penetration depth in the total test force and remains at the level of the residual indentation depth (h - expressed in units of 0.002 or 0.001 mm). This is also referring to as the depth differential (difference in indentation depth before and after application of the total test force).

- Now the Rockwell hardness (HR) can be calculated, using the residual indentation depth (h) and a formula defined in the standard, taking account of the applied Rockwell scale.

Table 1 Experimental details of hardness value

S. No.	Type of the material	Indenter	Load 60kgf (Br)	Load 60kg(Row)	Load 100kgf (Br)	Load 100kgfRow)
1	PURE SISAL+METAL	¼ ball	415	44	100	30
2	PURE HEMP+METAL	¼ ball	264	28	90	43
3	PURE FLAX+METAL	¼ ball	135	75	102	97
4	HEMP+SISAL+METAL+FLAX	¼ ball	156	83	125	62
5	SISAL+HEMP	¼ ball	373	40	115	70
6	FLAX+HEMP	¼ ball	552	55	109	93
7	FLAX+SISAL	¼ ball	388	42	112	65
8	SISAL+HEMP+FLAX	¼ ball	245	24	183	95

2.2 Tensile Testing method

Standard test method, ASTM D3039[19] for tensile properties of fiber reinforced composite has used to test the unidirectional composite specimens. The standard test method, ASTM D3039, for tensile properties of composites and standard method of testing rigid sheet are refer in preparing and testing the specimens. The composite materials used in the current study comprise of natural fiber and unsaturated polyester resin. The standard specimen size required is adopt for the present study.

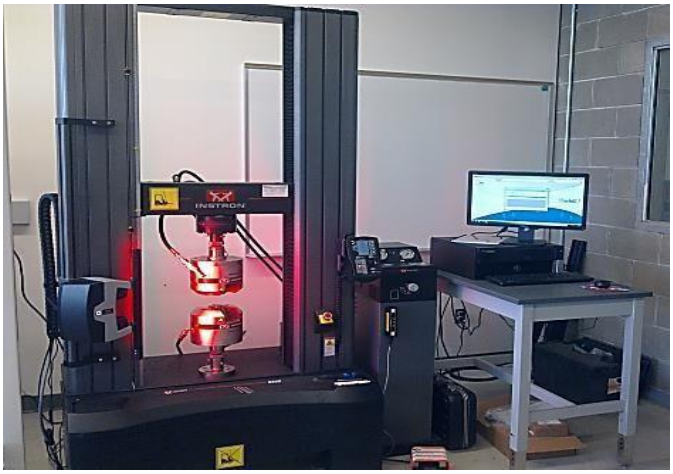

Figure 4 Instron machine

Test procedure:

Specimens placed in the grips of a Universal Test Machine at a specified grip separation and pulled until failure. For ASTM D3039 the test speed can determined by the material specification or time to failure (1 to 10 minutes). A typical test speed for standard test specimens is 2 mm/min (0.05 in/min).

An extensometer or strain gauge used to determine elongation and tensile modulus. Depending upon the reinforcement and type, testing in more than one orientation may be necessary. State-of-the-art equipment including Align-pro for reduced bending.

Elevated or reduced temperature test procedure:

A thermal chamber installed on a Universal Test Machine and allow the test mounts from the base and crosshead of the Universal Tester to pass through the top and bottom of the chamber. Standard test fixtures are installed inside the chamber, and testing is conduct inside the controlled thermal environment the same as it would be at ambient temperature. The chamber has internal electric heaters for elevated temperatures and uses external carbon dioxide gas or liquid nitrogen as a coolant for reduced temperatures.

Specimen size:

The most common specimen for ASTM D3039 is a constant rectangular cross section, 25 mm (1 inch) wide and 250 mm (10 inch) long.

2.3 Volatile test analysis:

This standard focuses on composites with thermosetting resins that lose a few percent of the matrix mass when heated due to loss water and low molecular weight matrix constituents that volatilize during heating.

Figure 5 Muffle Furnace

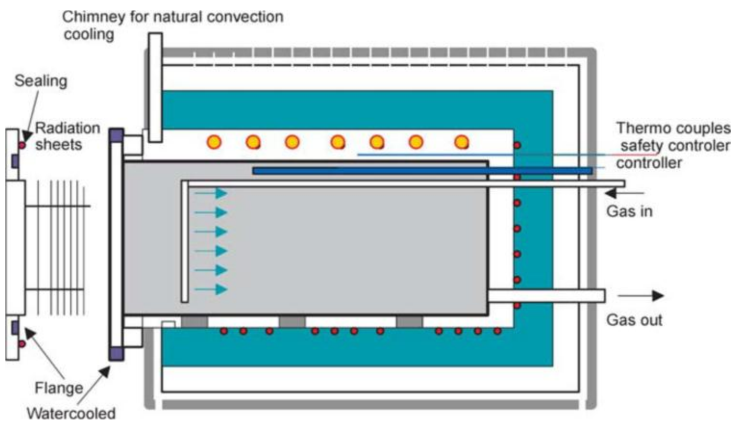

Figure 6 Internal structure of Muffle Furnace

Test Procedure:

Three specimens, with a minimum cross-sectional area of 1600 mm^2 machined from customer-supplied product. The specimens weighed on an analytical balance to the nearest 0.1 mg and place in an oven at the nominal cure or consolidation temperature for a period of 15 minutes, then removed from the oven, placed in a desiccator, and allowed to cool. The specimens are then reweighed and volatile content is calculated.

Specimen size: Three specimens, with a minimum cross-sectional areas of 1600 mm^2.

Data:

The volatiles content calculated as follows: 9 VC = (Mi – Mf) / Mi x 100

Where, Mi=initial weight

Mf= final weight

3. Result and discussion

3.1 Hardness Test

Hardness is a measure of the resistance to localized plastic deformation induced by either mechanical indentation or abrasion. Below the graph is drawn between reinforced fibre with metal and without metal.

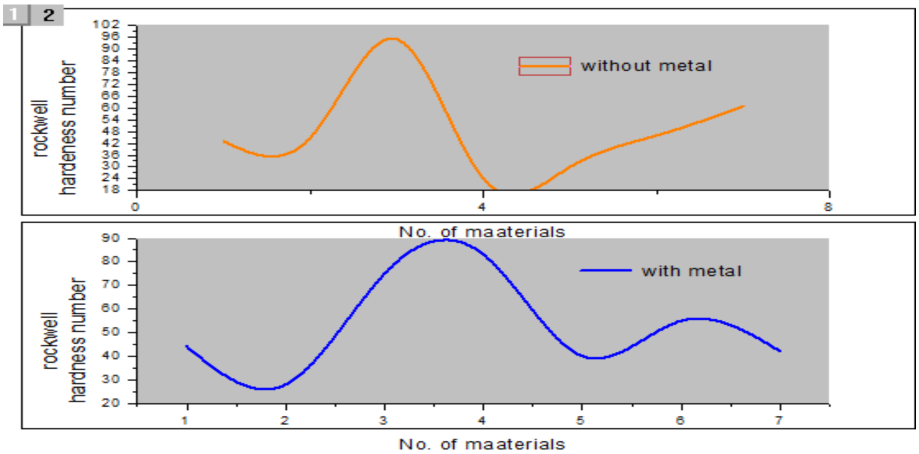

Figure 7 BHN vs number of specimens

3.2 Tensile Test:

An object or medium under stress becomes deformed. The quantity that describes this deformation is called strain. Strain under a tensile stress is called tensile strain. In the below, the graph indicates the reinforced composite material is subjected to 10N load. The deformation and the values of break value are given the table listed below.

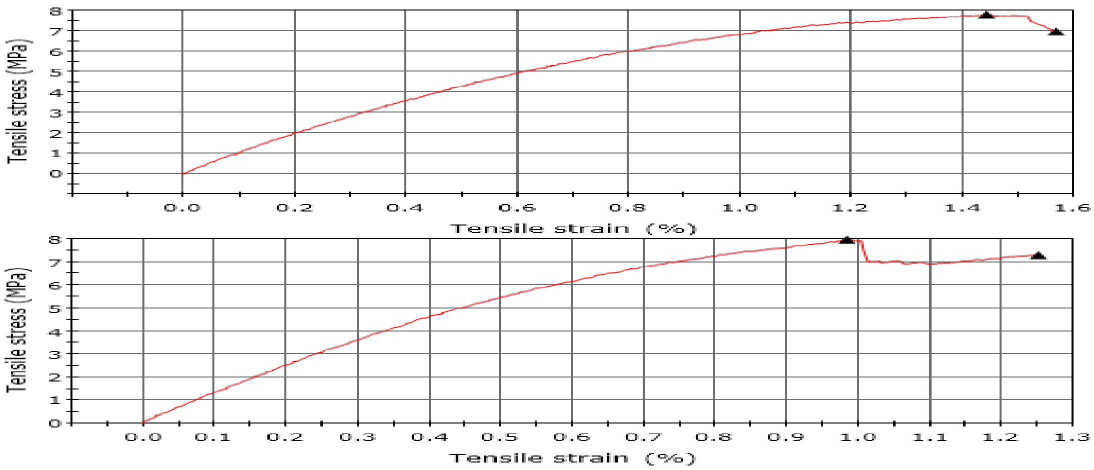

Figure 8 Tensile stress vs Tensile strain (without metal)

Table 2 Tensile percentage of following composite materials

S. No.	Type of the material	Maximum Load	Load at Break (kn)	Load at 2% Strain	UTS (MPa)
1	PURE SISAL+METAL	1.68	1.30	-	6.20
2	PURE HEMP+METAL	1.67	1.25	-	6.12
3	PURE FLAX+METAL	1.69	1.32	-	6.34
4	HEMP+SISAL+METAL+FLAX	1.79	1.58	-	7.96
5	SISAL+HEMP	1.52	1.15	-	6.08
6	FLAX+HEMP	1.57	1.18	-	5.98

7	FLAX+SISAL	1.53	1.20	-	5.92
8	SISAL+HEMP+FLAX	1.62	1.25	-	7.79

3.3 Volatile test analysis:

Table-3 volatile percentage of following composite materials

Composite name	Mass (kg) Mi	Mass (kg) Mf	Volatile formula (%) (Mi-Mf)/Mi x 100
Hemp+flax+sisal	0.010	0.008	20
Hemp+sisal+metal+flax	0.015	0.012	20
PURE SISAL+METAL	0.016	0.014	20
PURE HEMP+METAL	0.01	0.008	20
PURE FLAX+METAL	0.008	0.006	20

In the present investigation, sisal, flax and hemp fiber, reinforced natural composites are prepared with three different fiber weights and two different fiber orientations. Mechanical properties such as flexural and hardness properties are evaluate as per the ASTM standards. Based on the experimental results and analysis, the following conclusions are drawn.

4. Conclusions

From the analytical and experimental investigation on sisal, flax and hemp fibers reinforced polymer composites the following conclusions have been concluded:

- The Ultimate tensile strength of 7.96 MPa was absorbed by the reinforced composite sample (HEMP+SISAL+METAL+FLAX) followed by sample (SISAL+HEMP+FLAX) and it has been able to withstand the Ultimate tensile strength of 7.79 MPa.
- Micro molecular weighted impurities content is negligible amount in all the samples and water vapor presence are also equal to zero.
- The maximum hardness number is 183 observed for sample (SISAL+HEMP+FLAX)followed by sample (HEMP+SISAL+METAL+FLAX) with hardness value of 105.

From the above we can conclude that the values of UTS for reinforced composite sample with metal and without metal are similar with minimum difference. The hardness value of reinforced composite for metal is low when compared it with reinforced composite without metal. So in the future if we start implementing the natural fibres by reducing synthetic materials we can make environmental friendly components which are natural fibre composites. This will increase the green technology.

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