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Characterization Of Aloevera/Hemp And Flax Natural Fibre Composites With Wire Mesh Reinforcement For Automobile Applications

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ABSTRACT

Natural fibre-reinforced polymeric composites utilityis increased by the automotive industries due to their advantages such as recyclability, cost- effectiveness, light weight, high strength, rigidity and ecological production. The natural polymeric fibre-hybrid composite overcomes the concerns of the mechanical properties of mono-material fibre-reinforced composites.

This investigation involves using Aloe Vera (A), Hemp (H), and flax (F) fibres in the Hybrid Natural Fibre Polymer (HNFPC) composites for different applications. Natural Fibres Wire Mesh Composite (NFWMC) plates were fabricated using woven A/H/F along with Stainless Steel Wire Mesh (SSWM), aluminium wire mesh (ALWM) and copper wire mesh (CUWM). A Total of 15 variants of samples were fabricated using hand-layup and through compression moulding techniques.The Experimental trial-I samples were prepared with A/H, F/H, A/F and A/H/F combinations along with LY556 and HY951. In trial-II the samples were prepared by adding $BaSO_4$ in variousweight ratios (1%, 3%, 5% and 7 %). The optimum results were obtained for sample with 5% of $BaSO_4$ addition, and hence the samples uses in the first trial combinations with 5% of $BaSO_4$were preferred for trial-III. Finally, alongwith 5% of $BaSO_4$the experimental trial-IV samples were fabricated using stainless steel, aluminium and copper wiremesh.

The mechanical properties of the composite materials were determined by the tensile, flexural, impact and hardness properties. The Visco-elastic properties were estimated by the Dynamic Mechanical Analysis (DMA). The thermal performance of the

composites was investigated using Thermo Gravimetric Analysis (TGA). The machining performance was evaluated by Abrasive Water Jet Machining (AWJM) and wear analysis. This research work focuses mainly on the effect of barium sulphate ($BaSO_4$) and wire mesh on the characteristics of Hybrid Natural Fibre Reinforced Polymer (HNFPC) composite. The $BaSO_4$was preferred as filler based on the absence of self-motion, high density and high melting point (1580°C).

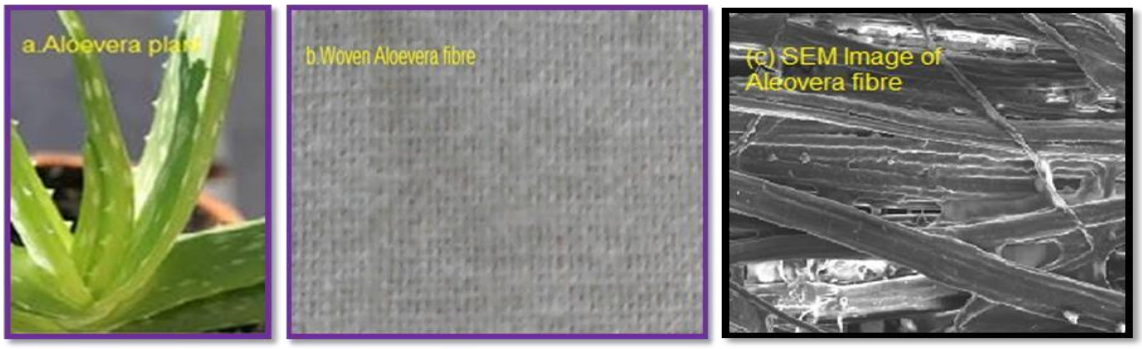
INTRODUCTION

Composites are often defined as distinct Components that are chemically related and physically dissimilar parts separated by a fixed limit for the benefits like low weight, decomposition conflict, outstanding fatigue strength, and increasing assembly speed. A wide range of application for Fabrication of aircraft structures, Construction of home-built spacecraft and medical equipment. The prime materials applied in our everyday lifespan are timber, concrete, ceramic ware.Amazingly, the first critical polymeric composites remain to originate in environment, then exist referred to as natural composites. The connective materials of creatures were belonging to the category of advanced polymer composites, later man made revolutions identified the strengthening of protein, collagen composites. It serves connective material which has both flexible and tough.The composites are selected for their better specific strength and stiffness as these properties helps to reduce fuel usage and increase the strength during transport. This results in faster movement and installation of robot arms eradicating the necessity supporting foundations or structures. Composites are not corroded, which decreases the necessity of maintenance and painting. Excellent fatigue resistance and corrosion resistance increases the merchandise lifespan of composite bearings for marine engines and bridges. Hybrid Composite materials such as strengthened carbon fibre, Kevlar, fibres, are used in manufacturing of aerospace spares. The advantage of using fibre-reinforced syntheses isweight drop. Fibre-reinforced composite materials are used in many applications in locomotive production.Continuous Fibre CompositesIf the fibres are arrangedin amulti-axialalignmentor unidirectional orientation, then they are called continuous fibre composites.Thesecompositeshavethevery best modulus andstrength in the longitudinal bearing of the fibres. But in atransverseway, themodulus and strength exist relatively small.Woven Fibre Composites Delaminationofthelaminatesis asevere problem within the continuous fibre laminate. This is often due to the fact that fibres arenot straight, and they pulled out due to improper processing conditions. This aspect reduces the stiffness and strength.Chopped Fibre Composites In the chopped fibre composite the uniform mechanical and physical properties are obtained with a random orientation of fibres. Chopped fibre composites are utilized in high-volume applications due to low manufacturing cost.Hybrid Fibre Composites which involve more than two combinations of fibresarehybridfibres.Not onlyfibres,insome cases,fibreswithfillers in a common matrix are additionally said to be hybrid composite. Hybridization produces a different range of properties as observed widely by many researchers. The material cost is reduced to a largeextent, and the outcomeof hybridization attains high performance. A

number of the combinations of fibres like banana/sisal, glass/banana, glass/sisal, oil palm/sisal, glass/oil palm, pineapple/glass, and coir/glass, which produce better performance composites, have been concluded by earlier researchers by using optical fibre. Natural Balaji et al. (2017) studied the bagasse fibre. The composite is fabricated with poly condensation process. The bagasse fibre isextruded from locally collected sugar cane. It is to cut the fibres into pieces in varying form ranging between 10 mm to 20 mm and synthesizedwith 0, 5, 10, 15and 20 percentage of cardanol based bio-composite. Theauthorsalso carried out mechanical testing of these composites. The two sets of composites showed improved values in tensile, flexuralandimpact properties. Almahdi et al. (2020) studied the physical properties and water absorbent property of polymer-based composite made of chitosan, polybenzoxazine and clay mixed matrix composite aerogels.The composite is manufactured using thermal treatment of aerogels

MATERIALS

This research investigation considered three woven fibres (Aloevera, hemp& flax), threedifferentwiremesh(Aluminum,Stainless steel, and Copper wire mesh),filleraddition($BaSO_4$)andepoxymatrix(Ly 556 & Hy951).In the fabrication of composite, woven fabric or mats are frequently used for its convenient [92]. The weaving pattern of woven fibre in warp for horizontal and weft for vertical directions. They are classified based on their weaving patterns. Generally the woven fibre plays an major role in the significant of structural stability in the fabrication of laminate composites. Woven composites have a wide variety of applications in automobiles, aircraft, and biomedical components and in aerospace applications. Among these methods of weaving the fibres pain weaving method is selected for its simplicity and consistency

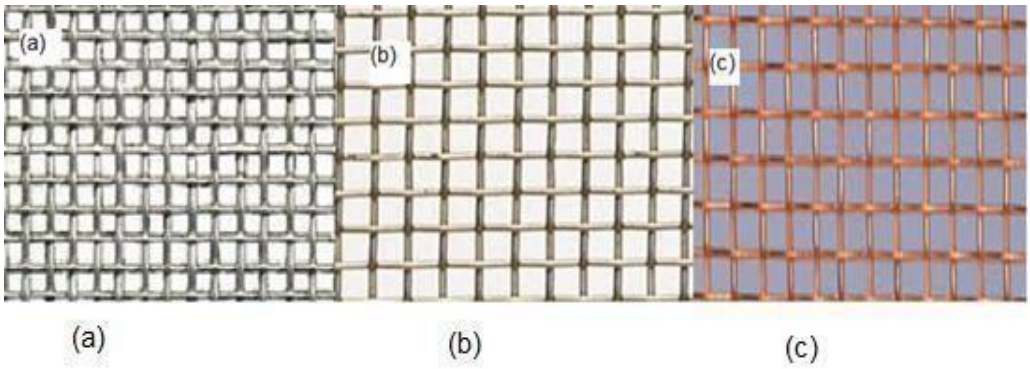


a) Aloevera plant (b) woven Aloevera fibre (120 GSM) (c) Microscopic image of Aloevera (diameter-0.3 mm)

Aluminum Wire Mesh and its Specification

There are three types of Wire mesh used in this research to fabricate the composite using the compression molding method, they are as follows; Wire mesh required for the

fabricationofcompositeisAluminum and was purchased in square form. Figure 3.5(a) represents an aluminummesh of diameter- 0.25mm and area of 300 x 300 mm [42]. Advantageof using aluminum wire meshes having good strength, moreductility,andmore tensile property



a) Aluminum wire mesh (b) Stainless steel wire mesh (c) Copper wire mesh

Hand Layup MethodHand layup method is one of the most widely used techniques to fabricate the industrial components to the desired state of composites shapes. The hand layup practice as shown in the Figure 3.9. Theprocedure is a by preparing glass plate mould for the required dimensions and place the resin, filler mixture with help of brush. The first layer places the wax and the fibre is arranged one by one according to our standard dimensions required. In between that the resin is applied .the steel roller is used to roll above the fibre mat to avoid the excess resin present in the mold.

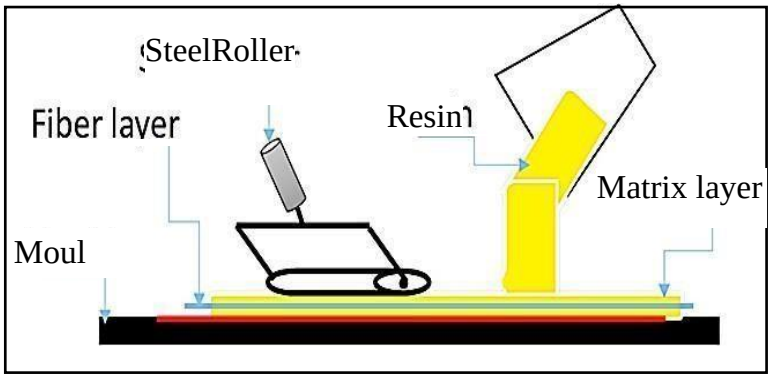


Figure Schematic representation of Hand layup process

CHARACTERIZATION OF COMPOSITES

Depending upon the type of test, different ASTM standards were used throughout the testing process. The types of testing which are used to evaluate the composites are listed belowMechanical characterization

- Tensile test

- Flexural test
- Impact test
- Hardness test

Water absorption

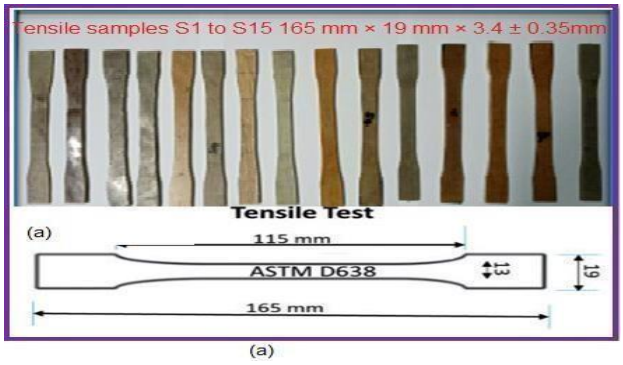
Dynamic mechanical analysis

Thermo gravimetric analysis(TGA)

MECHANICAL CHARACTERIZATION

Tensile Testing of Composites

In this research tensile testing, flexural testing, impact testing, and hardness for the material is determined. We shall discuss about the mechanical testing of the materials. The test is carried out in Universal Testing Machine (UTM), the test is carried out with 3 samples Aloevera, hemp, and flax with and without $BaSO_4$.The specimen before and after testing was shown in the



3.8.1 Flexural Testing

Flexural test for a composite is performed to understand the performance of the tested materialwhen subjected to a bending force. Though the flexure testing_s can be performedby severalroutes,a UTMisused inthis research[37]. The flexural test is applying three loads at three different points on the specimen placed over a supporting beam. Thetestprocedures and samples were prepared according to ASTM D790-17 standards

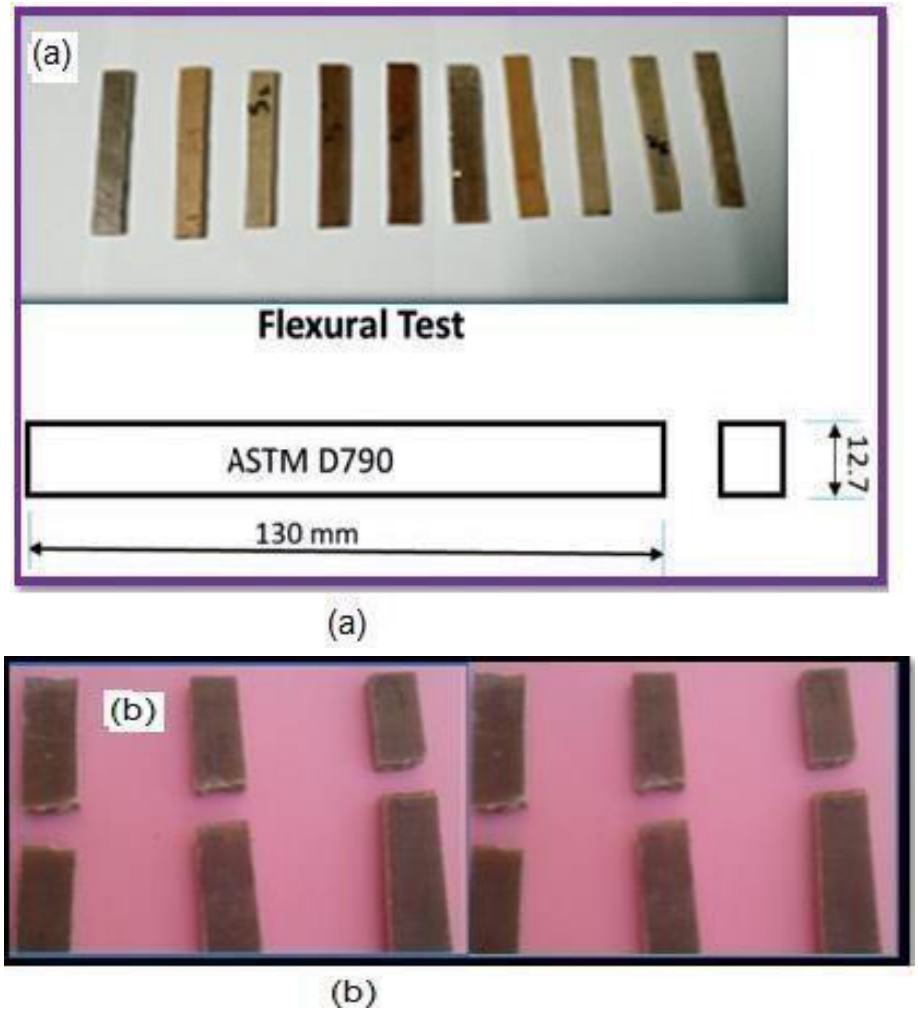


Figure 3.15 Photographic image of the flexural specimen (a) Before testing(b) After testing

3.8.2 Thermo Gravimetric Analysis (TGA)

Thermo gravimetric analysis for material is performed to understand the thermal withstanding ability of the composite. The prepared specimen is tested using Nietzsche TGA/DTA 6200 at under controlled heating in Nitrogen atmosphere pyric software controls the

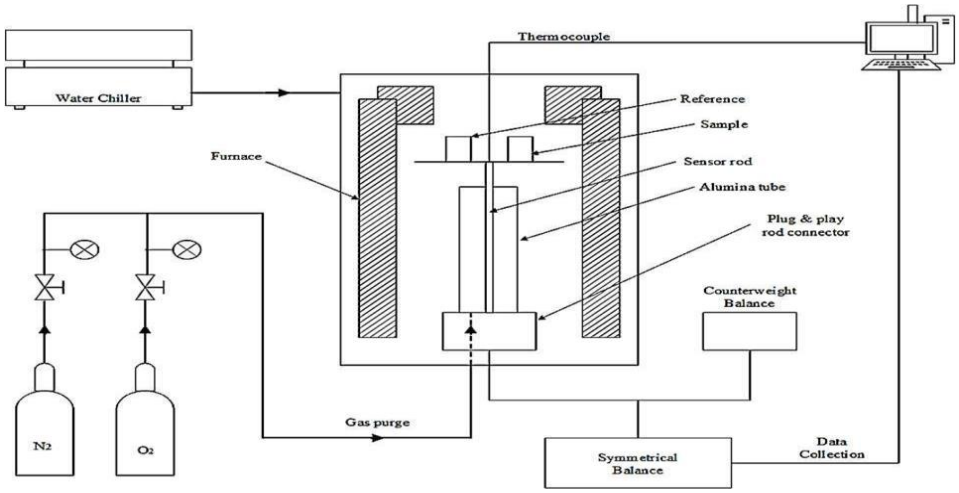


Figure 3.20:

Schematic illustration of the TGA apparatus

Results and discussion

The tensile test is carried out to understand the behavior under tensile load. From the obtained tensile test the load-displacement and stress-strain curves are used for the discussions. In this research the different experimental trial results are correlated to identify the suitable materials for the manufacturing of automobile component. To summarize all the values of tensile strength for all samples in experimental trial- I, II, III and IV is shown Initially through the experimental trial –I S1, S2, S3 and S4 Hybrid fibre polymer composite (HNFPC) are analyzed. It consists of Aloe Vera, hemp and flax fibres. The load-displacement curves for the sample S1 to S4is shown in figure 5.2(a). The load-displacement andstress-strain plotsof the standard specimens were obtained from theautomated computerized UTM machine. Among these four samples,S4 possess better tensile load carrying ability which

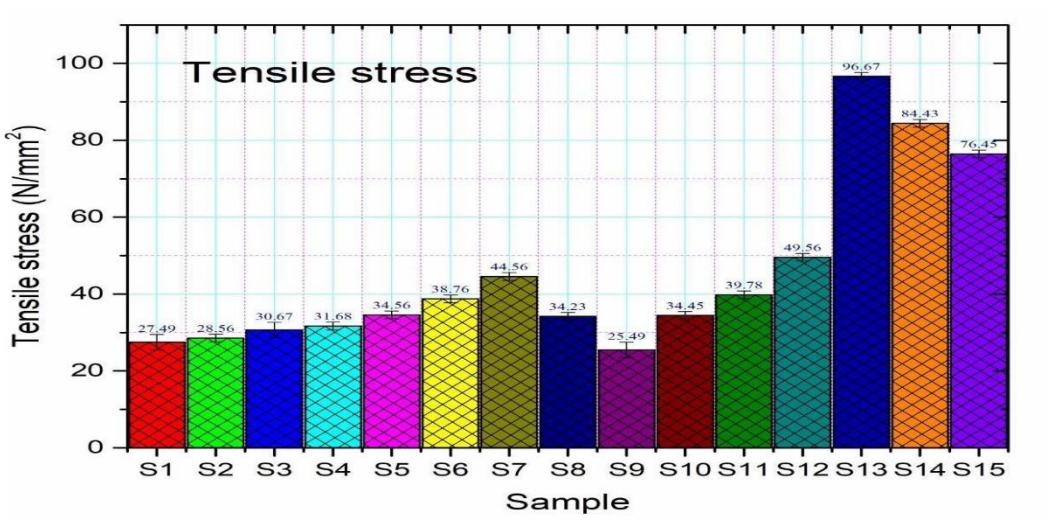


Figure 5.1 Tensile stress values of all the samples

Flexural TestingThe composite withstand load below the deflection value ofFlexural testing is done to understand the material performance. A simple supported beam is illustrated as point loads acting in it to flexural load. The flexural testing

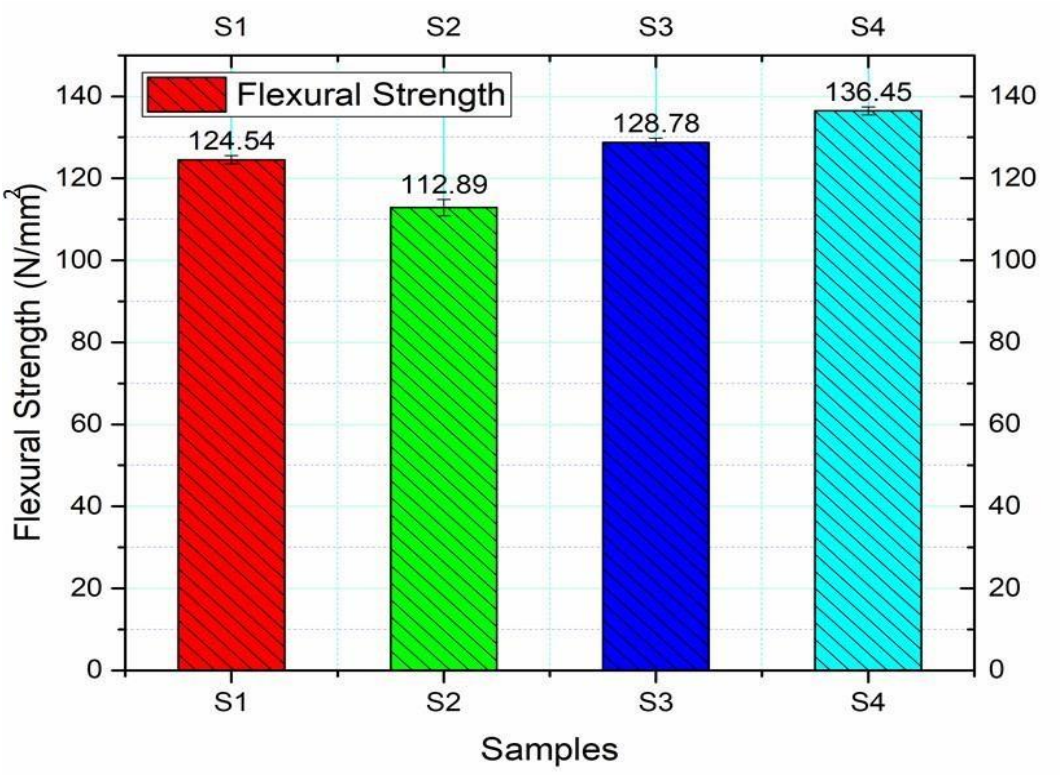


Figure : Flexural strength of Trial-I samples S1, S2, S3 and S4

6.1 CONCLUSION

The research observations concludes the following conclusionsare made

- The chemical treatment of fibres is enhanced the mechanical and dynamic mechanical analysis property.
- The maximum tensile strength is observed in the sample S13 has achieved 96.67N/mm^2 than the remaining samples.
- The impact results proved that the stainless steel wire meshed composites had more energy absorbing ability before the fracture is 65 J/m.
- The flexural strength of the natural fibre hybrid composite influenced by the $BaSO_4$ filler. The sample S12 hasobserved the highest value of 164.56 N/mm^2 due to the three fibres,

- The effect of wire mesh influences the mechanical property that enhances the tensile strength of 58.8%, flexural Strength of 53.8%, impact energy of 56.9%, and hardness of 25.4% compared to hybrid natural fibre composites.
- Owing to the low water solubility of $BaSO_4$, the inclusion of $BaSO_4$ minimized the water absorption capability of the sample S13 achieved 35.45% percentage when compared to the other samples composites.

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