Characterization of Glass Fiber Composite with Bi-directional 45^0 Orientation reinforcement using VARTM

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Abstract

Glass fiber composites are extensively utilized in various industries like Automobile, Aerospace, Defence, Safety equipments due to their superior mechanical properties and lightweight nature. The findings of this research contribute to enhancing the understanding of the mechanical performance of glass fiber composites with bidirectional 45-degree orientation . The types of glass fibers are C-glass, S-glass and E-glass. The C-glass fiber is designed to give improved surface finish. S-glass fibers design to give very high modular, which is used particularly in aeronautic industries. The E-glass fiber is a high quality glass, thus The E-Glass fibre is found appropriate for this Experiment which is used as standard reinforcement fiber for all the present systems well complying with mechanical property requirements.This study focuses on the characterization of glass fiber composite materials with bidirectional 45-degree orientation by using Vaccum Assisted Resin Transfer Moulding process (VARTM) . Through a combination of experimental analysis and numerical simulations, the mechanical behavior, including tensile, flexural and Toughness properties of the composite material is investigated.

Keyword:- Bi-direction composite, E-glass fiber, VARTM

INTRODUCTION

E-glass fiber, also known as electrical glass fiber or ECR glass fiber, is a type of fiberglass made from alumino-borosilicate glass. It's widely used in various industries due to its excellent mechanical properties, thermal resistance, and electrical insulation properties. E-glass fiber have high tensile strength. They can withstand high temperature without significant losses of strength or deformation. They have excellent electrical insulation properties and are resistant to most chemicals. E-glass fibers are commonly used as reinforcement in composite materials such as fiberglass reinforced plastics (FRP), providing strength and stiffness to the composite structure. These composites find applications in automotive parts, aerospace components, marine vessels, construction materials, and sports equipment. Bi-directional composite materials typically refer to composite materials reinforced with fibers oriented in two primary directions, usually perpendicular to each other. These materials are designed to provide strength and stiffness in two principal directions, offering improved mechanical properties compared to unidirectional composites. Bidirectional composites are reinforced with fibers oriented along two primary axes, typically at 0 and 90 degrees (or other orthogonal angles). Bidirectional composites exhibit anisotropic properties, meaning their mechanical properties vary depending on the direction of loading. They have higher strength and stiffness along the fiber directions (0 and 90 degrees) compared to other directions. Bidirectional composites offer high tensile strength in both primary directions, making them suitable for applications requiring strength in multiple directions. They also have good flexural strength, allowing them to withstand bending loads in both principal directions. The bidirectional arrangement of fibers provides good impact resistance, particularly when the impact occurs along one of the primary fiber directions. Vacuum Assisted Resin Transfer Molding (VARTM) is a manufacturing process used to produce high-quality composite parts with complex shapes and excellent mechanical properties. It's a variation of the resin transfer molding (RTM) process and is particularly suited for large, lightweight structures. The use of vacuum pressure during resin infusion helps to minimize voids and air bubbles within the composite part, resulting in improved mechanical properties and surface finish. VARTM allows for precise control over resin flow and distribution throughout the part, ensuring uniform resin content and fiber wet-out. VARTM is well-suited for manufacturing parts with complex geometries and internal structures, as it allows for the production of intricate shapes without the need for costly tooling modifications.

METHODOLOGY

A. Selection of Material:

1. Fiber Selection:-

The commonly used fibers are carbon, glass, kevlar, etc. Among these, the glass fiber has been selected based on the cost factor and strength. The types of glass fibers are C-glass, S-glass and E-glass. The C-glass fiber is designed to give improved surface finish. S-glass fiber is design to give very high modular, which is used particularly in aeronautic industries. The E-glass fiber is a high quality glass, which is used as standard reinforcement fiber for all the present systems well complying with mechanical property requirements. Thus, E-glass fiber was found appropriate for this application.

2. Glass Fiber Details:-

Glass fiber properties, such as tensile strength, Young's modulus, and chemical durability, are measured on the fibers directly. Other properties, such as dielectric constant, dissipation factor, dielectric strength, volume/surface resistivities , and thermal expansion, are measured on glass that has been formed into a bulk sample and annealed (heat treated) to relieve forming stresses. Properties such as density and refractive index are measured on both fibers and bulk samples, in annealed or unannealed form ASTM C 693 is one of the test methods used for density determinations. The Glass Fiber used are 200GSM, 220GSM, and 300GSM

3. Resin Selection:-

In a FRP leaf spring, the Inter laminar shear strengths are controlled by the matrix system used. Since these are reinforcement fibers in the thickness direction fiber do not influences Inter Laminar Shear strength. Therefore, the matrix system should have good inter laminar shear strength characteristics compatibility to the selected reinforcement fiber. Epoxies show better inter laminar shear strength and good mechanical properties. Hence, epoxide is found to be the best resins that would suit this application. Different grades of epoxy resins and hardener combinations are classifieds, based on the mechanical properties.

Details of Epoxy Resin:-

I. Epoxy Resin LY-556
II. The epoxy resin and epoxy hardener were mixed in the ratio of 10:1.
III. Visual aspect – Clear, pale yellow liquid
IV. Viscosity at 250 C – 10000-12000 MPa
V. Density at 250 C – 1.15-1.20 gm/cm3
VI. Flash point – 1950

Details of Epoxy Hardener:-

I. Epoxy Hardener 851
II. Visual aspect – Pale yellow liquid with a slight odour
III. Viscosity at 25C – 8000-15000 MPa
IV. Density – 0.98g/cm3
V. Flash Point – 205^0C

A. Composition of the Specimen:-

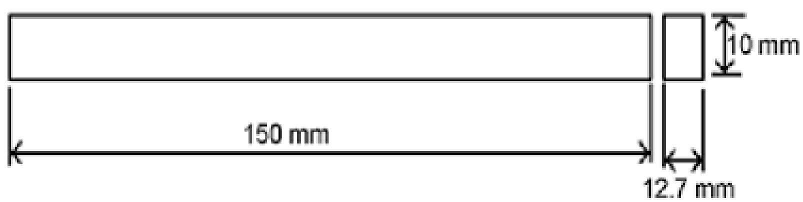
The Composition of 200GSM, 220GSM and 300GSM are (60:40) in which 60% is Fiber and 40% is Resin + Hardener. In Resin and Hardener, the Resin is 70% and Hardener is 30%.

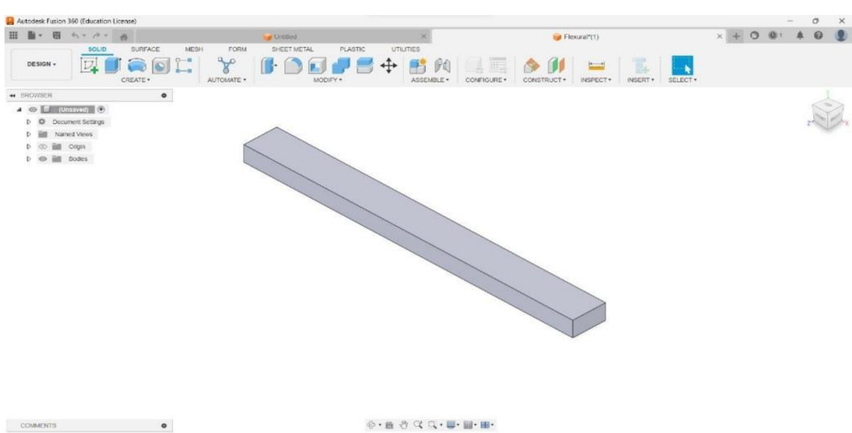
TESTING

The specimen is been made of 200GSM, 220GSM and 300GSM. The 3 test which are going to be performed on the specimen are Flexural (ASTM D 790), Izod Impact (ASTM D 256) and Tensile (ASTM D 638).

1) Flexural Test and ASTM D790:-

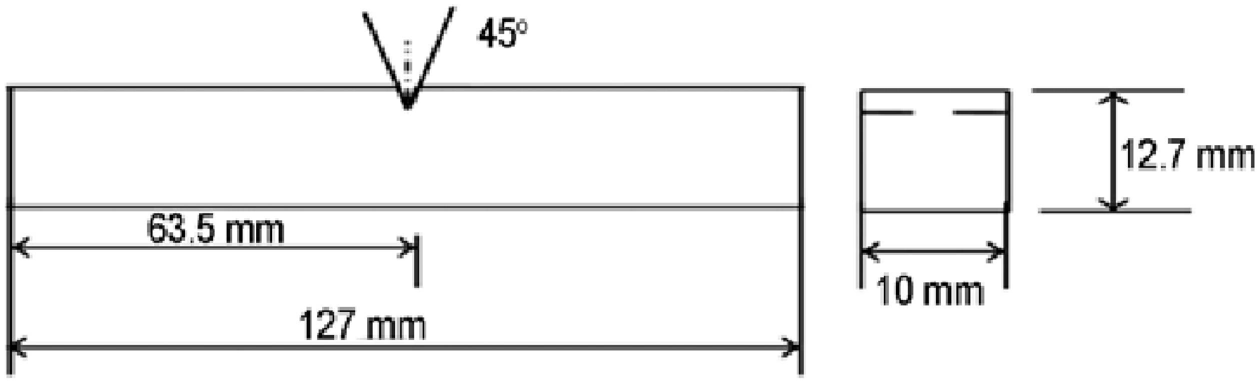
A flexural test, also known as a bending test, is a mechanical test used to determine the strength and stiffness of a material when subjected to bending loads. It involves applying a force to a specimen until it bends or fractures. The results provide valuable information about the material's behavior under bending stress, which is crucial for designing and evaluating structural components. Typically, the test involves a three-point or four-point bending setup, where the specimen is supported at two points while a load is applied at a third or fourth point to induce bending. ASTM D790 is a standard test method established by ASTM International for determining the flexural properties of reinforced and unreinforced plastics and electrical insulating materials. The standard is titled "Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials." ASTM D790 provides procedures for determining the flexural strength, flexural modulus, and other aspects of the flexural behavior of plastics and electrical insulating materials. These properties are essential for understanding how materials respond to bending loads. The standard specifies the size and shape of test specimens, as well as the preparation methods. Specimens are typically rectangular in shape and are machined or molded according to specific dimensions. ASTM D790 outlines the procedures for conducting flexural tests using either a three-point or four-point bending setup. The choice of setup depends on factors such as material type and test requirements. The test involves applying a load to the center of the specimen at a constant rate until it deflects or fractures. During the test, measurements of load and deflection are recorded. Based on the collected data, ASTM D790 provides formulas for calculating flexural properties such as flexural strength, flexural modulus, and strain at break.

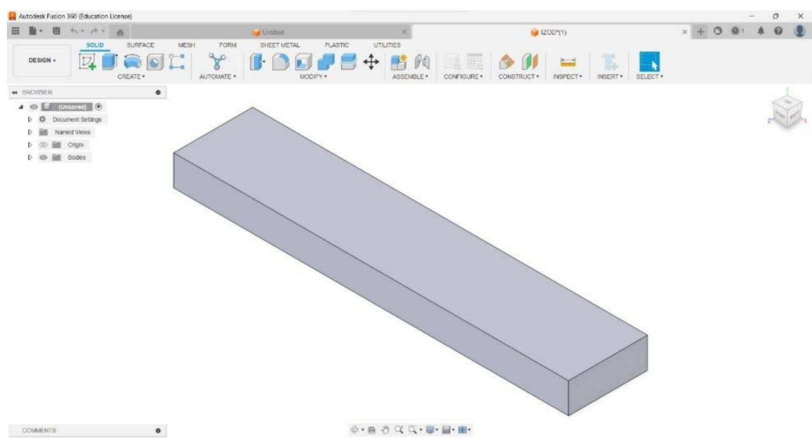




2) Izod Impact Test and ASTM D256:-

The Izod impact test is a standard method for determining the impact resistance or toughness of a material, particularly plastics. The Izod test measures the energy required to break a notched specimen under a single blow from a swinging pendulum. It evaluates a material's ability to absorb energy during impact, which is crucial for assessing its suitability for applications where it may experience sudden impacts or shocks. Test specimens are typically rectangular in shape and contain a V-notch or notch of specified dimensions. The notch serves to concentrate stress and facilitate controlled fracture during the test. Specimens are prepared according to specific standards, such as ASTM D256. In the Izod impact test, the specimen is clamped vertically, and a swinging pendulum with a striking edge strikes the specimen at the notch. The pendulum's energy before and after the impact is measured, allowing for the calculation of the impact energy absorbed by the specimen. The test results are typically reported as the energy absorbed by the specimen in joules (J) or foot-pounds (ft-lb). Higher values indicate greater impact resistance or toughness. The Izod impact test is standardized by organizations such as ASTM International (ASTM D256) and the International Organization for Standardization (ISO 180).

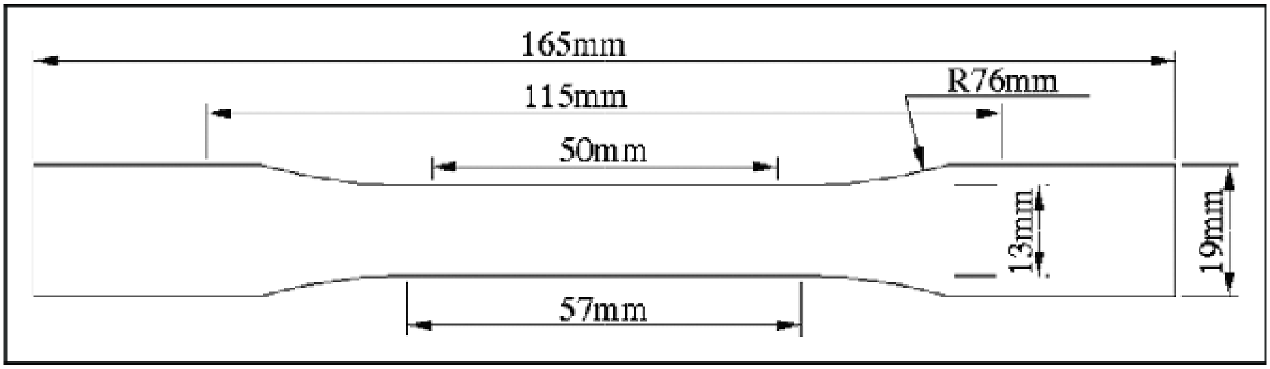


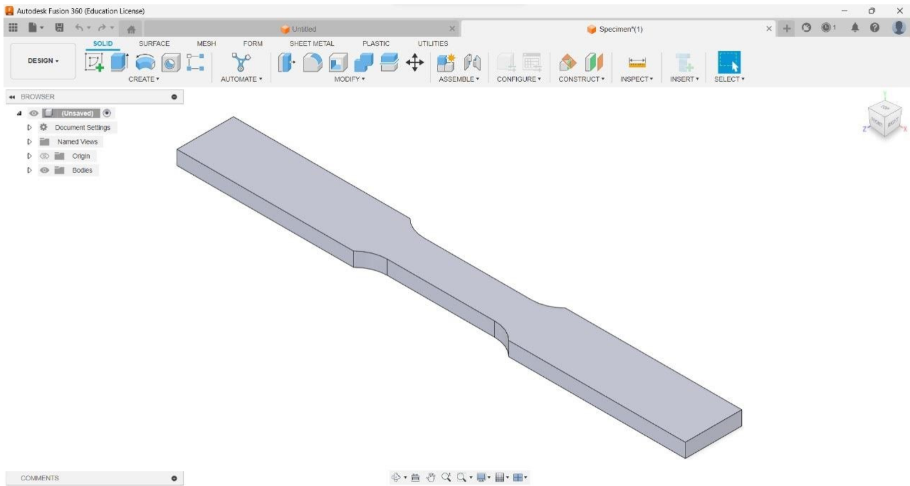


3) Tensile Test and ASTM D638:-

The tensile test, also known as tension test, is a fundamental mechanical test used to determine the mechanical properties of materials under axial tensile loading. The tensile test measures how a material behaves under tensile (pulling) forces, providing important information about its strength, ductility, elasticity, and other mechanical properties. Test specimens are typically cylindrical or flat, with a standardized shape and dimensions according to specific testing standards, such as ASTM E8 for metallic materials or ASTM D638 for plastics. Specimens may undergo machining or preparation processes to ensure uniformity and accuracy. During the tensile test, the specimen is clamped at both ends and subjected to a gradually increasing tensile force applied along its axis. The force is applied at a constant rate, usually controlled by a testing machine called a tensile testing machine or universal testing machine (UTM). As the test progresses, various parameters are measured and recorded, including the applied force (load) and the resulting elongation or deformation of the specimen. These measurements are used to generate a stress-strain curve, which illustrates the material's behavior under tensile loading. The stress-strain curve provides valuable information about the material's mechanical properties. It shows the relationship between stress (applied force per unit area) and strain (relative deformation) as the material undergoes tensile deformation. Key properties derived from the stress-strain curve include:

- Elastic Modulus: Also known as Young's modulus, this represents the material's stiffness deformation.
- Yield Strength: The stress at which the material begins to exhibit plastic (permanent) deformation.
- Ultimate Tensile Strength (UTS): The maximum stress the material can withstand before fracture.
- Ductility: Measured by the elongation or reduction in area of the specimen at fracture, indicating the material's ability to deform plastically before failure.





RESULTS

Glass fiber Specimen	Tensile strength (N/mm^2)	Flexural strength (Mpa)	Izod Impact strength (J/m)
200 GSM	90.5	78.38	3511
220 GSM	45.139	105.37	3937
300 GSM	238.471	362.69	2653

CONCLUSION

1. The design of Specimen geometry was done using Solidworks and Analysis was done using ANSYS Workbench . The Specimens were manufactured and testing using suitable methods.
2. The Flexural specimen with 300 gsm were found to exhibit the highest Flexural Strength of 362.69 Mpa
3. The Tensile specimen with 300 gsm were found to exhibit the highest tensile strength of 238.471
4. The Izod specimen with 220 gsm were found to exhibit the highest Izod impact strength of 3937 J/m

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