

Experimental Investigation of Hybrid Composites using Glass Fiber and Recycled Polyester

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Abstract - The composite materials are now replacing the traditional materials, Because of its superior properties such as high tensile strength, low thermal expansion, high strength to weight ratio. The developments of new materials are on the anvil and growing day by day. Polyester composites became more attractive due to easily recycled from waste plastic products and the cost of polyester is very low compared to natural fibres. Glass fibres reinforced epoxy composites will be prepared and the mechanical properties of these same will be evaluated. The composite sample with different fiber volume fraction will be prepared by using the hand layup process and apply pressure at room temperature. The sample where subjected to mechanical testing such as Hardness Test, Compression Test, Tensile Test and Impact Test respectively.

Key Words: Glass fiber, Polyester, Epoxy resin, Hardness test, Compression test, Tensile test, Impact test, etc...

1. INTRODUCTION

A Composite material (also called a composition material or shortened to composite) is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The interest in Natural Fibre reinforced polymer Composite materials is rapidly growing. They are renewable, cheap, completely or partially and biodegradable. These fibres are incorporated into a matrix material such as thermosetting plastics. A Fiber Reinforced Composite (FRP) is a composite material consisting of a polymer matrix imbedded with high-strengths fibres, such as glass, aramid and carbon. Fabrication of a composite fiber involves the combining of the Natural fiber (Reinforcement) with the Polymer (Matrix), these two are the building blocks of any

composite material. The most common procedure used for the fabrication of the natural composite is Hand-Layup process which includes the saturation of Natural fiber (Reinforcement) with the Polymer (Matrix). Layers of the Natural fiber are kept in a mould and resin is poured on each layer such that all layers are coated. Then a roller is used to roll over such that all layers gets coated well and extra resin comes out. Left undisturbed till the composite is ready.

1.1 INTRODUCTION TO COMPOSITES MATERIAL

A Composite material consists of two phases. If consists of one or more discontinuous phases embedded in a continuous phase. The discontinuous phase is usually harder and stronger than the continuous phase and is called the "reinforcement" or "reinforcing material", whereas the continuous phase is termed as the "matrix". The matrix is usually more ductile and less hard. It holds the dispersed phase and shares a load with it. Matrix is composed of any of the three basic material type i.e. polymers, metals or ceramics. The matrix forms the bulk form or the part or product. The secondary phase embedded in the matrix is a discontinuous phase. It is usually harder and stronger than the continuous phase. It serves to strengthen the composites and improve the overall mechanical properties of the matrix.

Properties of composites are strongly dependent on the properties of their constituent materials, their distribution and the interaction among them. The composite properties may be the volume fraction sum of the properties of the constituents or the constituent may interact in a synergistic way resulting in improved or better properties. Apart the nature of the constituent materials, the geometry of the reinforcement (shape, size and size distribution) influences the properties of the composite to a great extent.

The concentration distribution and orientation of the reinforcement also affect the properties. The shape of the discontinuous phase (which may be spherical, cylindrical, or rectangular cross-sectioned prisms or platelets), the size distribution (which controls the texture of the material) and volume function determine the interfacial area, which plays an important role in determining the extent of the interaction between the reinforcement and the matrix. Concentration, usually measured as volume or weight fraction, determines the contribution of a single constituent to the overall properties of the composites. It is not only the single most important parameter influencing the properties of the composites, but also an easily controllable manufacturing variable used to alter its properties (Abilash & Sivapragash 2013).

1.2 NATURAL FIBERS REINFORCED COMPOSITES

The interest in natural fiber-reinforced polymer composite materials is rapidly because of specific strength, stiffness and reduction in weight of natural applications and fundamental research. Plants, such as flax, cotton, hemp, jute, sisal, kenaf, pineapple, remie, bamboo, banana, etc., as well as wood, used from time immemorial as a source of lignocellulosic fibers, are more and more often applied as the reinforcement for polymer matrices. The natural fiber containing composites are more environmentally friendly, and are used in automobiles sectors, railway coaches, aerospace applications, military applications, building and construction industries (ceiling paneling, partition boards), packaging, consumer products, etc.

2. MATERIAL USED

2.1 Glass Fiber

Cheaper and more flexible than carbon fiber, it is stronger than many metals by weight, and can be molded into complex shapes. Applications include aircraft, boats, automobiles, bath tubs and enclosures, swimming pools, hot tubs, septic tanks, water tanks, roofing, pipes, cladding, casts, surfboards, and external door skins.



Fig 2.1 Glass Fiber

2.2 Polyester



Fig 2.2 Polyester

Polyester resins are unsaturated synthetic resins formed by the reaction of dibasic organic acids and polyhydric alcohols. Maleic Anhydride is a commonly used raw material with diacid functionality. Polyester resins are used in sheet moulding compound, bulk moulding compound and the toner of laser printers. Wall panels fabricated from polyester resins reinforced with fiberglass so-called fiberglass reinforced plastic (FRP) are typically used in restaurants, kitchens, restrooms and other areas that require washable low-maintenance walls. They are also used extensively in cured-in-place pipe applications. Departments of Transportation in the USA also specify them for use as overlays on roads and bridges. In this application they are known as PCO Polyester Concrete Overlays. These are usually based on isophthalic acid and cut with styrene at high levels usually up to 50%. Polyesters are also used in anchor bolt adhesives though epoxy based materials are also used. Many companies have and continue to introduce styrene free systems mainly due to odour issues.

2.3 Epoxy Resin



Fig 1.3 Epoxy resin

Epoxy is either any of the basic components or the cured end products of epoxy resins, as well as a colloquial name for the epoxide functional group. Epoxy resins, also known as polyepoxides, are a class of reactive prepolymers and polymers which contain epoxide groups. Epoxy resins may be reacted (cross-linked) either with themselves through catalytic homopolymerisation, or with a wide range of co-reactants including polyfunctional amines, acids (and acid anhydrides), phenols, alcohols and thiols (usually called mercaptans). These co-reactants are often referred to as hardeners or curatives, and the cross-linking reaction is commonly referred to as curing. Reaction of polyepoxides with themselves or with polyfunctional hardeners forms a thermosetting polymer, often with favorable mechanical properties and high thermal and chemical resistance. Epoxy has a wide range of applications, including metal coatings, use in electronics/electrical components/LEDs, high tension electrical insulators, paint brush manufacturing, fiber-reinforced plastic materials and structural adhesives.

3. MAKING PROCEDURE

3.1 Fabrication Process

The most commonly used manufacturing processes are introduced. Although many variants on these techniques exist, this overview gives a good indication of production possibilities.

Hand lay-up technique

The fibers, usually mats, are cut and placed in a mould, see figure. The resin is applied by rollers. One option is to cure while using a vacuum bag, and then it's called vacuum bagging. By applying vacuum, excess air is removed and the atmospheric pressure exerts pressure to compact the composite. Thermosets

commonly product is the boat hull. The advantages are the high flexibility and the simplicity of the process and the cheap tooling. The long production time, the labour intensive character and poor possibilities for automation are considered to be disadvantages.

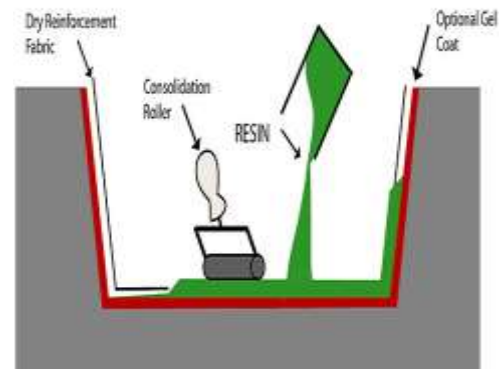


Fig 3.1 Hand lay-up technique

In our project is three different methods of the plates is formed and testing the materials.

- Impact test
- Compression test
- Hardness test
- Tensile test

Plate 1

Plate 1 is made up of

- Material used in the 100% glass fiber.

Plate 2

Plate 2 is made up of

- Material used in the 75% glass fiber and 25% polyester.

Plate 3

Plate 3 is made up of

- Material used in the 25% glass fiber and 75% polyester.

4. MACHINING PROCESS

4.1 Impact Test

The impact test is a method for evaluating the toughness and notch sensitivity of engineering materials. It is usually used to test the toughness of

metals, but similar tests are used for polymers, ceramics and composites. Metal industry sectors include Oil and Gas, Aerospace, Power Generation, Automotive, and Nuclear.

The notched test specimen is broken by the impact of a heavy pendulum or hammer, falling at a predetermined velocity through a fixed distance. The test measures the energy absorbed by the fractured specimen.



Fig 4.1 Experimental set up for Impact strength test

4.2 HARDNESS TEST

Hardness is a measure of how resistant solid matter is to various kinds of permanent shape change when a compressive force is applied. Some materials (e.g. metals) are harder than others (e.g. plastics). Macroscopic hardness is generally characterized by strong intermolecular bonds, but the behavior of solid materials under force is complex; therefore, there are different measurements of hardness: scratch hardness, indentation hardness, and rebound hardness



Fig 4.2 Experimental set up for hardness test

4.3 Tensile Test



Fig 4.3 Experimental set up for tensile testing

The test process involves placing the test specimen in the testing machine and slowly extending it until it fractures. During this process, the elongation of the gauge section is recorded against the applied force. The data is manipulated so that it is not specific to the geometry of the test sample. The elongation measurement is used to calculate the engineering strain, ϵ .

The preparation of test specimens depends on the purposes of testing and on the governing test method or specification. A tensile specimen is usually a standardized sample cross-section. It has two shoulders and a gage (section) in between. The shoulders are large so they can be readily gripped, whereas the gauge section has a smaller cross-section so that the deformation and failure can occur in this area.

$$\text{Tensile stress} = \text{Load} / \text{Area} (F/A)$$

Where,

F is the tensile force and

A is the nominal cross-section of the specimen.

The machine does these calculations as the force increases, so that the data points can be graphed into a stress-strain curve.

4.4 Compression Test



Fig 4.4 Compression Testing Machine

The compression specimen is prepared as per the ASTM D638 standard. A compression test involves mounting the specimen in a machine and subjecting it to the compression. The compression process involves placing the test specimen in the testing machine and applying compress to it until it fractures. The compress force is recorded as a function of displacement. During the application of compression, the elongation of the gauge section is recorded against the applied force. The compression test can also use to determine the ductility of a metal by observing the cracks that form on the barrelled cylindrical surface of the specimen. The hydrostatic pressure has a beneficial effect in delaying the formation of these cracks. With a sufficiently ductile material and effective lubrication, compression tests can be carried out uniformly to large strain. This behavior is unlike that in the tension test where, even for very ductile materials, necking can set in after relatively little elongation of the specimen.

6. TESTING RESULT

SPECIMEN	IMPACT ENERGY (Joules)	TENSILE STRENGTH (MPa)	COMPRESSION STRENGTH (MPa)	HARDNESS TEST
S1	6.41	84.12	8.71	57.6
S2	7.5	91.32	6.2	68.06
S3	7.23	83.73	5.955	72.06

6. CONCLUSIONS

The composite materials prepared from polyester, glass fiber and epoxy resin of various test specimen based on ASTM standards were tested under impact test, hardness test, tensile test and compression test. From this result the following conclusion derived.

From the above discussion, we conclude the specimen - 2 (OHP + Glass fiber + Glass fiber) gives better results when compared with others. So we may suggest this composite material (S-2) will be applicable for automotive components. is not mandatory.

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