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Study of stiffness characteristics of Aramid Fiber Wound Hybrid Pipe

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ABSTRACT: *The composite pipe are produced with variable reliability depending on their specific application. Reliability various with many factors like selection of materials, manufacturing process, environmental conditions and etc. Glass fiber, Aramid fiber and hybrid fiber was selected for control variable. pressure burst after compression either with stress corrosion or without stress corrosion was taken as response variable. The aim of this research work is to study about the effect of stiffness and find residual pressure of composite pipe. This study will also help to know the with stand of composite pipe. Composite materials are continuously gaining more importance in the field of engineering. In this paper we have focused mainly on hybrid fiber reinforced polymer composite materials as pipe. This work concentrates on the hybrid (Aramid and Glass) fiber as reinforcement for the epoxy matrix. The advantage of hybridization is to increase the strength such as hoop tensile, stiffness and compression. The aim of paper is to study the effect of compression of hybrid fiber pipe. We describe a method for making a lightweight, energy absorbing, glass fiber composite sandwich structure and explore it is through thickness (out-of-plane) compressive response*

KEY WORDS: Aramid fiber, composite pipe, epoxy matrix.

I. INTRODUCTION

Composite materials are materials were blend from two or more constituent materials with significantly different physical or chemical properties which will be more robust than the individual components. It gains major advantages such as stronger, lighter, less expensive. There are two major categories of constituent materials:

Matrix

The matrix material surrounds and supports the reinforcement materials by maintaining their relative position. Commonly known resins were polyester, vinyl ester, epoxy, phenolic, polyimide, polyamide, polypropylene.

SYTHENTIC FIBER

Synthetic fibers are made from synthesized polymers or small molecules. The compounds that are used to make these fibers come from raw materials such as petroleum based chemicals or petrochemicals. These materials are polymerized into a long, linear chemical that bond two adjacent carbon atoms. Differing chemical compounds will be used to produce different types of fibers.

Synthetic fibers account for about half of all fiber usage, with applications in every field of fiber and textile technology. Although many classes of fiber based on synthetic polymers have been evaluated as potentially valuable commercial products, four of them - nylon, polyester, acrylic and polyolefin - dominate the market. These four account for approximately 98 percent by volume of synthetic fiber production, with polyester alone accounting for around 60 per cent.[10]

There are several methods of manufacturing synthetic fibers but the most common is the Melt-Spinning Process. It involves heating the fiber until it begins to melt, then you must draw out the melt with tweezers as quickly as possible. The next step would be to draw the molecules by aligning them in a parallel arrangement. This brings the fibers closer together and allows them to crystallize and orient.

GLASS FIBER

Glass-reinforced plastic (GRP) is a composite material or fiber-reinforced plastic made of a plastic reinforced by fine glass fibers. Like graphite-reinforced plastic, the composite material is commonly referred to as fiberglass. The glass can be in the form of a chopped strand mat (CSM) or a woven fabric .As with many other composite materials (such as reinforced concrete), the two materials act together, each overcoming the deficits of the other. Whereas the plastic resins are strong in compressive loading and relatively weak in tensile strength, the glass fibers are very strong in tension but tend not to resist compression. By combining the two

materials, GRP becomes a material that resists both compressive and tensile forces well.[22] The two materials may be used uniformly or the glass may be specifically placed in those portions of the structure that will experience tensile loads.[4][Glass fiber is formed when thin strands of silica-based or other formulation glass are extruded into many fibers with small diameters suitable for textile processing. The technique of heating and drawing glass into fine fibers has been known for millennia; however, the use of these fibers for textile applications is more recent. Until this time, all glass fiber had been manufactured as staple (that is, clusters of short lengths of fiber). Composition. The most common types of glass fiber used in fiberglass is E-glass, which is alumino-borosilicate glass with less than 1% w/w alkali oxides, mainly used for glass-reinforced plastics. Other types of glass used are A-glass (Alkali-lime glass with little or no boron oxide), E-CR-glass (Electrical/Chemical Resistance; alumino-lime silicate with less than 1% w/w alkali oxides, with high acid resistance), C-glass (alkali-lime glass with high boron oxide content, used for glass staple fibers and insulation), D-glass
(borosilicate glass, named for its low Dielectric constant), R-glass (alumino silicate glass without MgO and CaO with high mechanical requirements as reinforcement), and S-glass (alumino silicate glass without CaO but with high MgO content with high tensile strength).

Properties

Glass fibers are useful thermal insulators because of their high ratio of surface area to weigt. However, the increased surface area makes them much more susceptible to chemical attack. By trapping air within them, blocks of glass fiber make good thermal insulation, with a thermal conductivity of the order of 0.05 W/(m·K).[10]

ARAMID FIBER(KEVLAR)

Aramid fiber is the generic name of a group of synthetic fibers. The fibers offer a set of properties which makes them particularly useful in armor, clothing and a wide range of other applications. The most commonly known commercial brand is Kevlar™, but there others such as Twaron™ and Nomex™ in the same broad family.

Properties

The chemical structure of the chain molecules is such that the bonds are aligned (for the most part) along the fiber axis, giving them outstanding strength, flexibility and abrasion tolerance. With outstanding resistance to heat and low flammability, they are unusual in that they do not melt – they merely start to degrade (at about 500 degrees Centigrade). They also have very low electrical conductivity making them ideal electrical insulators. With high resistance to organic solvents the all-round 'inert' aspects of these materials offers outstanding versatility for a huge range of applications. The only blots on their horizons is that they are sensitive to UV, acids and salts. They build static electricity too, unless they are specially treated. The outstanding properties which these fibers enjoy provide advantages which make them ideal for a wide range of applications. However, with any composite material, it is important to take care in handling and processing. Using gloves, masks, etc. is advisable.

BASALT FIBER

Basalt fiber is a material made from extremely fine fibers of basalt, which is composed of the minerals plagioclase, pyroxene, and olivine. It is similar to carbon fiber and fiberglass, having better physic mechanical properties than fiberglass, but being significantly cheaper than carbon fiber. It is used as a fireproof textile in the aerospace and automotive industries and can also be used as a composite to produce products such as camera tripods.

Basalt fiber is made from a single material, crushed basalt, from a carefully chosen quarry source and unlike other materials such as glass fiber, essentially no materials are added. The basalt is simply washed and then melted.[1]

The manufacture of basalt fiber requires the melting of the quarried basalt rock at about 1,400 °C (2,550 °F). The molten rock is then extruded through small nozzles to produce continuous filaments of basalt fiber. There are three main manufacturing techniques, which are centrifugal-blowing, centrifugal-multiroll and die-blowing. The fibers typically have a filament diameter of between 9 and 13 µm which is far enough above the respiratory limit of 5 µm to make basalt fiber a suitable replacement for asbestos. They also have a high elastic modulus, resulting in excellent specific tenacity—three times that of steel.

II. LITERATURE REVIEW

1.A.J MALCOME et al Compressive response of glass fiber composite sandwich structures Composites: Part A 54 (2013) 88–97

We have developed a method for making robust composite sandwich panel structures that appear well suited for impact loading applications. By combining three dimensional woven glass fiber fabrics that utilize z-yarn fibers to inhibit delamination, prismatic polymer foam inserts, and vacuum infusion of a rubber toughened epoxy, we have made a variety of corrugated core sandwich structures. The combination of Kevlar stitching of a corrugated E-glass core to higher strength S2 glass fiber face sheets, together with the large foam area of contact with the core webs and face sheets resulted in robust core-face sheet attachment and reliable load transfer. The quasi-static experiments reported here, and others conducted in the impact loading regime.

2. **JianXiong et al Mechanical behavior of sandwich panels with hollow Al–Si tub Light weight sandwich panels with hollow Al–Si alloy tube score construction Materials and Design 32 (2011) 592–597**.

Light weight sandwich panels with hollow Al–Si alloy tubescore and carbon fiber reinforced laminated panels were manufactured. The mechanical behavior and failure of the sandwich panel were studied under out-of-plane compression, in-plane compression, and three-point bending tests. The tube core offers high specific strength compared to stochastic and metallic cellular cores and thus, can be used to design light weight multi-functional structures.

3.**M.F.M. Alkbir et al Effect of Geometry on Crashworthiness Parameters of Natural Kenaf Fiber Reinforced Composite Hexagonal Tubes**

This paper presents the effect of geometry on energy absorption capability and load-carrying capacity of non-woven kenaffibre/epoxy composite hexagonal tubes with various angles have been investigated experimentally, under quasi-static axial compressive load. Based upon the test results the following conclusions can be made:

(1)The change of the hexagonal tube angle affects the crashworthiness parameters.

(2)The hexagonal tube with β =60°exhibited the best energy absorption capability compared to other tubes.

(3)Various distinct failure modes were observed namely, progressive failure mode, local bulking and transverse cracking failure mode one tube only reacted to catastrophic failure mode.

(4) High initial failure crush load leads to catastrophic failure mode as well as unstable post-crush stage.

(5)This investigation introduced a new indicator for catastrophic failure mode. It presents acriterion for determining withers the tubes crash in catastrophic or otherwise. When CFMI >80 % the first crushing mode type is catastrophic failure.

4.**AmirShahdin et al Fabrication and mechanical testing of glass fiber entangled sandwich beams: A comparison with honeycomb and foam sandwich beams Composite Structures 90 (2009) 404–412**

The aim of this paper is to manufacture and mechanically test glass entangled sandwich specimens in order to compare their performance with standard sandwich specimens having honeycomb and foam as core materials. The compression and bending test results show that the entangled sandwich specimens have a relatively low compressive and shear modulus when compared to honeycomb and foam sandwich materials. Vibration tests demonstrate the presence of high damping in the entangled sandwich specimens making them suitable for specific applications like the inner paneling of a helicopter cabin, even if the structural strength of this material is on the lower side. Furthermore, the vibration tests showed that entangled sandwich specimens possess in average 150% higher damping ratios and 20 dB lower vibratory levels than the honeycomb and foam sandwich specimens. The test results also proved that entangled sandwich specimens with shorter glass fiber lengths have high structural strength but on the other hand low damping ratios and higher vibratory levels when compared to entangled sandwich specimens with longer glass fiber length in the core. Thus, the entangled sandwich specimens can be fabricated according to the choice of the type of application, i.e., possessing higher rigidity or better damping characteristics. Impact tests shall also be carried out on these sandwich materials in future with glass fibers, honeycomb and foam cores in order to study the variations of modal parameters with impact damage and to evaluate the impact toughness of entangled sandwich materials.

(i) rural, agricultural economy of agricultural based countries like India;

(iii) It is biodegradable and non-toxic;

III. MATERIAL SELECTION

Glass fibers are widely used to produce Composite pipes which are widely used in oil and refinery industries and in transportation of natural gas. In this project glass fibers, Aramid fiber and hybrid fiber are used to produce composite pipes using by filament wound CNC machine.

The following materials are selected to prepare the laminate,

a. Glass fiber

b. Aramid fiber
c. Epoxy resin
d. Hardener
e. The mixing ratio for resin to hardener in weight (10:1)

Fig 4 Aramid fiber

Epoxy

Epoxy is the cured end product of epoxy resins, as well as a colloquial name for the epoxide functional group. Epoxy is also a common name for a type of strong adhesive used for sticking things together and covering surfaces,[1] typically two resins that need to be mixed together before use. It can also be used as a solver due to its high melting and boiling points. Epoxy resins are low molecular weight pre-polymers or higher molecular weight polymers which normally contain at least two epoxide groups. The epoxide group is also sometimes referred to as a glycidyl or oxirane group.

FILAMENT WINDING

Filament wound GRP pipes were manufactured using a CNC winding machine with winding Angles of 90°. FG STRAND 1200 TEX, E-Glass which is alumino-borosilicate glass with less than 1% w/w alkali oxides, mainly used for glass-reinforced plastics and Araldite Epoxy Resin Grade LY556 -A epoxy resin system and Huntsman - Grade - ARADUR HY951 i s a hardening agent were used to make specimens. Before winding operation, resin was mixed for 4–5 min at 40°C resulting in an appropriate viscosity with a 4-h gel Time. Three layer specimens were produced by winding onto the release agent and resin coated and preheated Mandrel heated to 60°C. Filament wound composite pipes were produced with dimensions of 250 mm in length, 50 mm inner diameter and 2.5 mm in an average thickness and were cured for room Temperature / 24 - 48 hours on the mandrel in a slow motion rotary oven. All production stages were repeated to make 90° filament wound pipes. The pipes were cut into the designed test length using a diamond Wheel saw.

Burn off test

Burn-off tests were performed in accordance with ASTM-D2584. Resin matrix was burned completely in an electric oven at 600°C. The volume fractions of fiber, which determines pipe strength and rigidity, were computed from weight loss of samples. Burn-off specimens were weighed using a 0.01 mg precision scale. Volume fraction (Vf) of 90 ° pipes were found to be .45.

Fig 7 Burn-off test

Fig 8 Specimen after Burn-off test

3.4. SPECIMEN PREPARATION

As per ASTM D2412-02 standard , specimen was prepared

For thermosetting pipe, the test specimen shall be a piece of pipe 6±1/8 in. (150±3mm)long. For reinforced thermosetting resin pipe ,the minimum test specimen length shall be three times the nominal pipe diameter or 12.0 in (300),whichever is smaller .for pipe larger than 60 in.(1524 mm) in diameter , the minimum specimen length shall be 20% of the nominal diameter adjusted to the nearest 1 in.(25.4mm).The end of the specimens shall be cut square and shall be free of burrs and jagged edges.no less than three specimen shall be tested for each sample of pipe.

The test specimen is 150mm length , 50mm inner diameter, 50mm outer diameter and thickness of the pipe is 2.5mm

NUMBER OF SPECIMENS

They are four specimens used in the process follow us

1. Glass fiber with epoxy resin
2. Aramid fiber with epoxy resin
3. Glass and aramid with epoxy resin
4. Aramid and glass with epoxy resin

STIFFNESS TESTING

Fig 9 glass fiber in testing machine

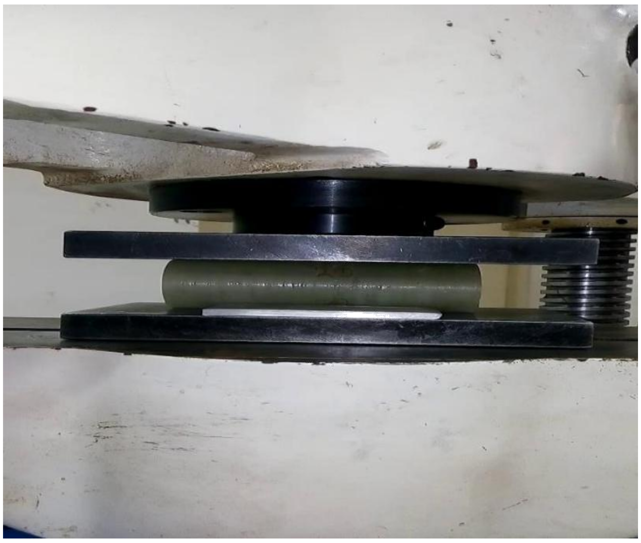

Fig 10 glass fiber in UTM machine

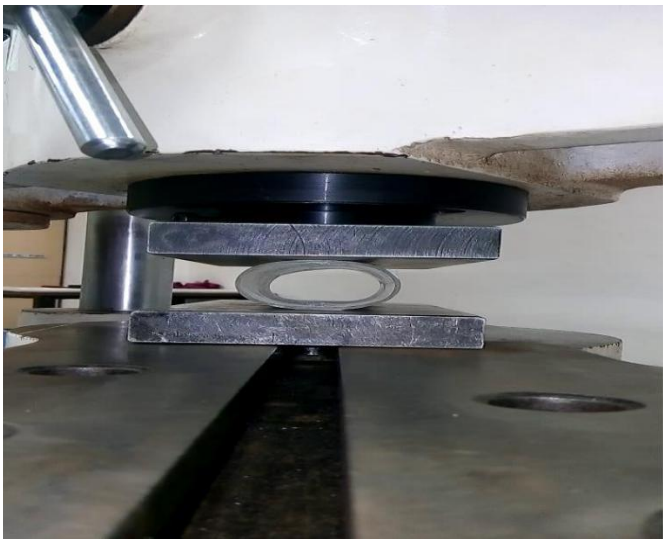

Fig 11glass fiber in UTM machine

IV. RESULT AND DISCUSSION

LOAD VS TIME

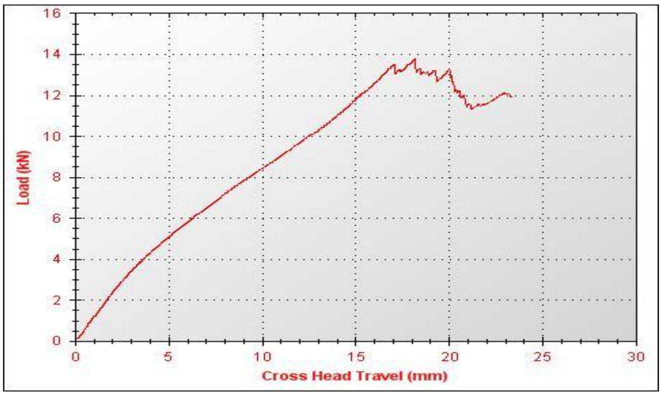

Fig 12. (Aramid 25% Epoxy 50% Glass 25%)

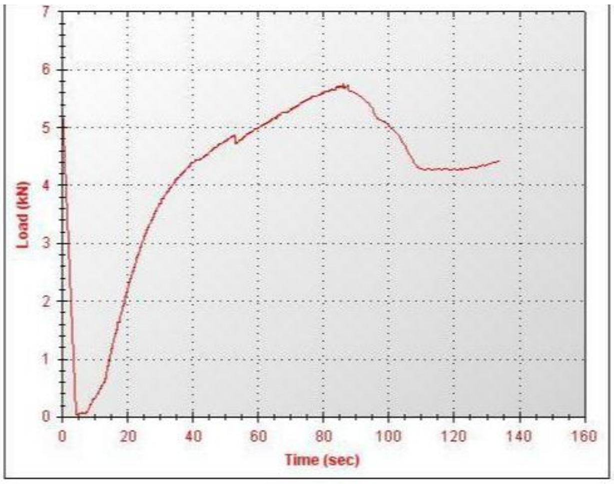

Fig 13. (Aramid 50% Epoxy 50%)

Fig 15. (Glass 25% Aramid 25% Epoxy 50%)

From absorbing above four graphs for load vs time ,we compare each other specimen. we found that glass and aramid with epoxy have high load withstand(15kn and 380 sec) and have low load withstand is (5kn and 90 sec) aramid fiber with epoxy.

V. CONCLUSIONS

It was observed that when the material undergoes stiffness test when load is applied to the composite material, wall crack , fiber layer delamination was initated at the surface of pipe .From the above test specimen we absorbed that in first graph (glass and aramid with epoxy) have high load withstand and (glass and epoxy) have high load withstand. In second graph (glass and aramid with epoxy)have high load withstand and (aramid with epoxy) have low load withstand. In third graph (glass and aramid with epoxy) have high load withstand and (aramid with epoxy) have low load withstand. In final graph (glass and aramid with epoxy) have high load withstand and (aramid with epoxy)have low load withstand. Finally we observed that glass and aramid with epoxy have high stiffness.

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