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Investigation on Mechanical Behavior of Braided Glass Fiber Pipe

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Abstract:
Braiding is a relatively less explored textile process for producing composite preforms. In recent years braiding technology have received much more attention because of its rapid automated method for forming an interwoven structure, high level of conformability and good damage resistance capability. Braiding method is a product of textile technology and usually utilises equipment adapted from the textile industry. In this project composites pipe is produce using braided glass fibre as filament material and epoxy resin as matrix. The various parameters such as braid angle, braid patterns and number of over braids which effect the braided preform characters are varied and their performance are analysed by using ANSYS 14.5 simulation software and mechanical testing of the resultant composite materials.

Keywords **—braided glass fiber, ANSYS 14.5, resultant composite**

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I. INTRODUCTION

The braiding process involves the weaving of fibres into shape by repeatedly crossing them back and forth over a mandrel. Braiding is the formation of comparatively narrow rope like structures by interlacing diagonally three or more strands of yarn. In conventional braiders, yarn carriers rotate along a circular track; with half the carriers rotating in a clockwise direction while the remaining carriers rotate in counter clockwise direction, similar to a maypole arrangement. As a result, the two sets of yarns interlace with each other at a bias angle to the machine axis. Braiding has traditionally been used for producing textile structures such as shoelaces and ropes. However, in recent years, fibre reinforced composites and medical implants have become interesting application areas for braiding.

II. LITERATURE SURVEY

Hunt. Richard (MS. EE) ; The paper brings out the untitled study involving an electronic control system to accomplish unlimited interlacing patterns in woven structures produced by braiding; to include 1.) Logic and control circuitry, 2.) Motor and synchronization components and 3.) Yarn movement components.

Sartain. Steven (MS, TS); This paper describes about untitled study of weaving and braiding to include 1) a comparison of weaving and braiding structures, processes and mechanisms, 2.) a review of testing systems used on woven and braided structures and 3.)a comparison of the behavioral and tensile properties of woven structures and slitted, tubular braids.

Vickers. Daniel (MS ME); This paper presents the Untitled study of novel concepts and mechanisms used to accomplish yam interlacing in a braiding process to include; 1.) an evaluation of various arrangements of moving and stationary yam carriers, 2.) design and evaluation of various innovative interlacing devices and concepts.

III. METHODOLOGY

A. *Problem Identification*

- To fabricate an alternative light weight pipe for the conventional metal pipes.
- Metal pipes need anti corrosion treatment to prevent from rusting and corrosion, this increases the cost of manufacturing.
- The cost of metal pipes keeps on increasing as raw materials cost increases.
- We suggest braided composite pipes can be used as an alternative for conventional metal increase.
- We chose glass fiber as filament material because more than 75% of the industrial composite materials use glass fiber as the filament material either in continuous form or discontinuous form.
- We use epoxy resin as matrix material because of its excellent bonding and corrosion resistance characteristics.

B. *Methodology*

- Braiding of the glass fibre yarn is carried out in conventional textile braiding machine
- Composite glass fibre pipe is fabricated using braided EC-R glass fibre and epoxy resin with fibre and volume fraction of(60% fibre and 40% resin) with upto two over braid
- The glass fibre pipe fabricated using different braid layers of fibre and volume fraction(60% fibre and 40% resin) were subjected to mechanical testing.
- The best results from various ratios were selected for further fabrication with over bratestin.
- The fabrication process were done using hand layup technique.
- The mechanical properties such as Tensile, Torsion and Flexural were analysed to find the loading capacity of pipes.
- The simulation behaviour of braided pipe is carried out using ANSYS14.5 Analysis Software.

IV. EXPERIMENTAL PROCEDURE

C. *MaterialSelection*

The following materials are used in this project

1) E-CR Glass fibre
2) Braiding machine
3) Epoxy resin
4) Hardener

D. *Braiding Process:*

The braiding process involves the weaving of fibre into shape by repeatedly crossing them back and forth over a mandrel. The method is a product of textile technology and usually utilises equipment adapted from the textile industry. The braiding carries follow a zig zag path in a large circle surrounding the mandrel.

1) **Step-1:** Converting roving into yarns

Roving is a loosely associated bundles of untwisted bundles or strands of filaments. Each filament diameter in roving is the same. Since the roving cannot be directly loaded into the braiding machine carriers. We need to convert the roving into yarns.
Yarn is a closely associated bundle of twisted filament or strands. Each filament diameter in yarn is same. Number of filaments for the yarn is chosen and the filament are loaded into yarn making machine.The yarn making machine rotates the bobbin to load the filament into it, at the same time it controls the tension of the filament. So that the filament can be loaded into the bobbin in correct pattern without any fuzzy.

Fig. 1 EC-R Glass fibre Roving

2) Step-2:

Yarn bobbin are loaded into the yarn carriers and the filament are loaded into the takeup mechanism of braiding machine through yarn tension controllers. The yarn tension controllers helps to maintain the correct tension while braiding. If the tension is not maintained properly it will result in a fuzzy braid and it will result in improper braid angle and braid pattern.

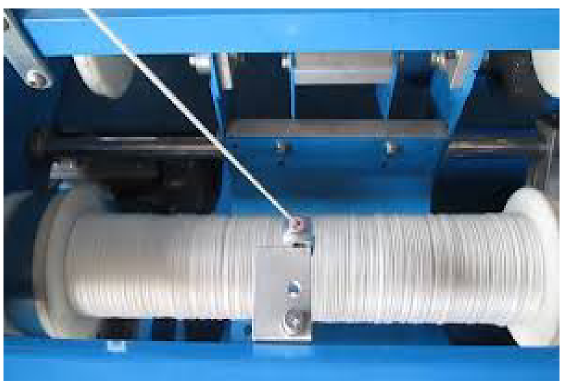

Fig.2 Glass Fibre Yarn spun into bobbins

3) Step-3:Braiding

Yarn carriers are rotated by horn gears and guided by track plate. The horn gears inturn are driven by electrical motor connected through gear drive. The takeup mechanism velocity depends on the speed of horn gears,as the takeup mechanism is driven by preset gear drive as per the required braid angle. The braided preform is rolled into the takeup wheel which can be unloaded once the process is completed.

Braid angle is determined by

$\alpha = \tan^{-1}(\omega R/v)$

α = braiding angle (between threads and vertical direction)

ω = average angular velocity of bobbins around the machine centre (rad/s)

R = radius of cylindrical mandrel (cm)

V = take-up speed (cm/s)

Each affiliation must include, at the very least, the name of the company and the name of the country where the author is based (e.g. Causal Productions Pty Ltd, Australia).

Email address is compulsory for the corresponding author.

E. Hand Layup Process:

Hand Lay-up is the simplest and oldest open molding method of the composite fabrication processes. It is a low volume, labor intensive method suited especially for large components, such as boat hulls. Glass or other reinforcing mat or woven fabric or roving is positioned manually in the open mold, and resin is poured, brushed, or sprayed over into the glass plies.

Entrapped air is removed manually with squeegees or rollers to complete the laminated structure. Room temperature curing polyesters and epoxies are the most commonly used matrix resins. Curing is initiated by a catalyst in the resin system, which hardens the fiber reinforced resin composite without external heat. For a high quality part surface, a pigmented gel coat is first applied to the mold surface. This technique is also called as contact layup in the open mould method of molding thermosetting resins in association with fiber. The Layup technique was shown

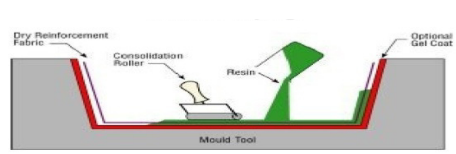

Fig.3 Hand Lay-up process

Fig.4.Actual tools used in Hand lay-up

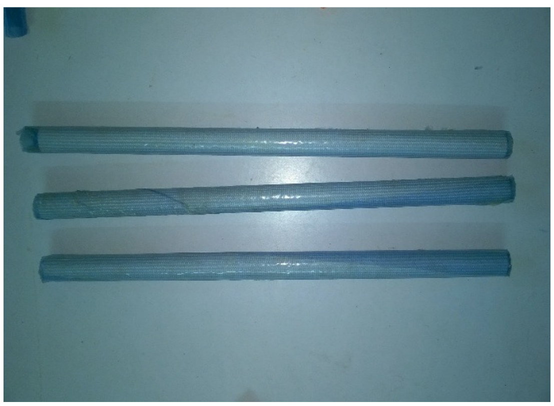

Fig.5. Resultant Composite Pipe

V. EXPERIMENTAL RESULT

F. *ANSYS Simulation*

1) *Tensile simulation*

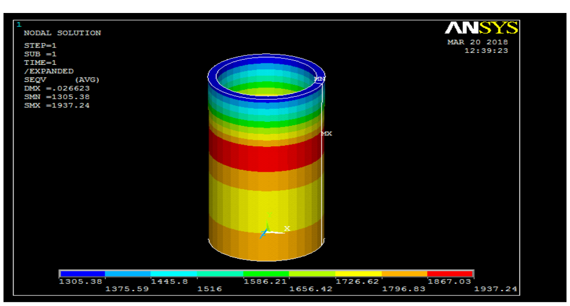

Fig. 6 Tensile analysis of single layer

G. *MechanicalPropertyTesting*

The Following mechanical properties of the EC-R Glass fiber composite materials reinforced with Acaia for different volume of fraction 30-70 & 40-60 were determined during this investigation.

1.Tensile strength

2.Flexural strength

It is the maximum stress that a material can withstand while being stretched or pulled before necking, when the specimen cross section starts to significantly contract. It is found by performing a tensile test and recording the stress versus strain; the highest point of the stress strain curve is the ultimate tensile stress. It is an intensive property; its value does not depend on the length of the test specimen. It is dependent on other factors, including preparation of the specimen, the presence of surface defects, and the temperature of the test environment and material.

Tensile test was carried out by applying tensile load. Tensile test was carried out by using universal testing machine. Testing speed is 5mm/min. The specimen size is 300mm*9mm dia as per ASTM D3039/D3039M, ISO 527-4(Test method for tensile properties of

Fig. 7 Tensile analysis of single layer

Fig. 8 Tensile analysis of single layer

Flexural Strength:

Flexural test was carried with the three point load of two side supported and load acting on the centre of the specimen. By continuously increasing the load acting on the specimen we calculated the deformation of the different volume of fraction. According to ASTM D790 standard 127mm*12.7mm*4mm of the specimen had made by hand layup method. The volume fraction of fibre is 40, and 60% the 3 point bending test setup is shown

VI. CONCLUSIONS

In this project we conducted a literature survey on different types of braiding machine. Based on the study we learnt the principle and working of a braiding machine. Then we designed various components like bevel gear, worm gear, spur gears and belt drives for biaxial braiding machine, which is designed by means of Creo 3.0 3D modeling software, based on those theoretical calculations done parts were fabricated. Then each component is fabricated by means of various processes like turning, gear hobbing, drilling, milling and welding. Finally the parts are assembled manually and placed on support table. Various aspects in braiding is specified through the literature study. Since braided structures have more strength when compared to other processed structures braiding has better scope for future work. And braiding of the two strands of yarns is carried out.

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