INVESTIGATION ON ENERGY ABSORPTION OF NATURAL AND HYBRID FIBRE UNDER AXIAL STATIC CRUSHING

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CHAPTER 1

INTRODUCTION:

Most vehicle body frames are thin-walled steel columns. The rails at the front and rear body of cars are the main energy-absorbing parts in a crash. The bumpers of a vehicle may play a role for a minor frontal or rear impact, when the vehicle collides with a pole or a tree at a relatively low speed, such as in a car park. Therefore, there is a need to enhance the energy absorption and control the mode of failure of thin shell tube made from the composite materials and use it instead of metallic materials in the structural parts of the vehicles to provide more protection for passengers during accidents. Many studies have been done on that using different types of fibers, different geometries and using types of foams or fillers. The results showed that T-laminates have better residual properties but sudden failure of the jute fiber limits their use. Q-laminates showed good performance due to their high impact energies and ease of control. Major constituents in a fiber-reinforced composite material are reinforcing fibers, and matrix that acts as a binder for the fibers. Coupling agents, coatings, and fillers may be found as other constituents. Coupling agents and coatings are applied to fibers to improve their wetting with the matrix, as well as to promote bonding across the fiber matrix interface. Both, in turn, promote a better load transfer between the fibers and the matrix. Fillers are used with some polymeric matrices primarily to reduce cost and improve their dimensional stability.

Epoxy resins dominate the aerospace composites market, especially the family of epoxy resins which compose 176.66 ^{0}C curing that enhances the results in laminates, which have unique mechanical properties. Curing epoxies with Lower temperature (121.11 ^{0}C) and below), compared with vinyl esters, have static mechanical properties. Epoxy, compared with polyester and vinyl esters, has the highest values of fracture toughness, which may lead to increase the fatigue performance of the laminates. Another big difference is that the shrinkage of the epoxies is relatively low at about 3%, while vinyl shrinks about 8% during cure. Cracking during the cure of thick pieces of high curvature can be caused by high cure shrinkage of vinyl esters. Hand lay-up, is an old, simple, labor intensive method for manufacturing low-volume composite. It is particularly suitable for large components such as boat hulls. Any reinforced material such as glass, mat, or woven roving is placed manually in the open mold, and then the resin is poured or sprayed on the reinforced material. Woven roving should be used as an alternative to the layers of chopped strand mat. A combination of woven roving and chopped strand mat is presented by many suppliers to reduce the costs of labor and to prevent omitting of the chopped strand mat by mistake. Woven roving enhances the strength and rigidity of the mold, but it is difficult to get them out with resin, and they do not match easily with the shape of the mold.

ABSTRACT:

Using metallic materials in vehicles structures increases cost and fuel consumption, therefore, the trends start to use cheaper and lite materials. Fibers are used in composites in automotive applications because they are lightweight, stiff, and stronger than bulk material, as well as achieve comparable energy absorption to metallic materials. The aim of this research is to investigate the potential of natural fiber in the applications of crash energy absorption. An experimental procedure (hand layup) was applied to investigate the effect of using jute fiber on crash worthiness parameter of composite material with other types of fibers such as Kevlar and glass fiber reinforced epoxy composite. The work involved fabrication the tubes using three layers, two geometries (circular and square) with three different heights at constant crush speed 1.5 mm/sec. The results show that the tubes of jute fiber were ineffective and failed directly, but, replacing one layer of jute fiber by one layer of other types of fibers lead to an enhancement in crash worthiness parameters especially, failure type and crash worthiness parameters. The better results are achieved when using hybrid jute and Kevlar, where the energy absorption is enhanced by 17.75 % and the specific energy absorption is enhanced by 25.122% in case of circular tube with diameter 50 mm. In case of square tube with length 50 mm, the results are enhanced by 62.764 % for energy absorption and 58.942% for specific energy absorption.

Keywords – hand layup; energy absorption; jute fiber; crash worthiness parameters; crushing

EXPERIMENTAL SETUP:

A.GEOMETRY AND MATERIALS:

Twenty four samples have been investigated with two geometries circular and square using two diameters for the circular and two sides length for the square. Three layers of fibers were used with orientation 0-90. The tubes made from Jute fiber and hybrid fiber.

B.PREPARATION OF MANDREL:

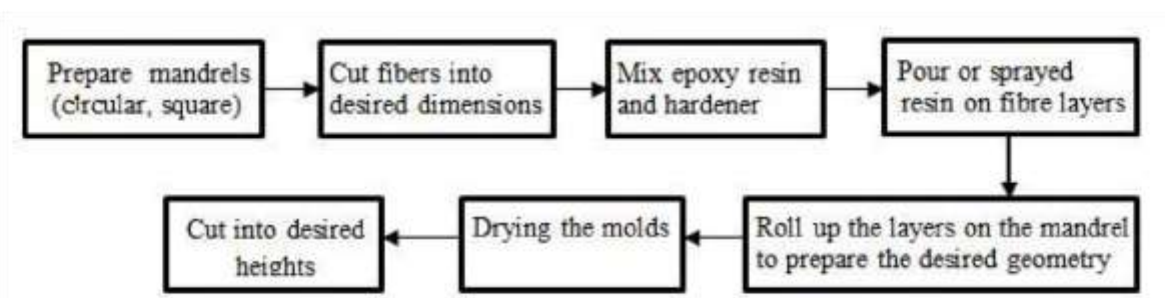
After preparation of the materials, the second step started with preparation of the mandrels. The geometries of mandrels have been used is circular which were manufactured from wood in the work shop with 310 mm height and 50mm for the diameter.

The parts of the mandrel were bound by a tape to prevent any movement. Then, the mandrel was covered by a layer of weak nylon or plastic to prevent the epoxy from sticking to the mandrel, which could affect the tubes through extraction.

C. FABRICATION PROCESS:

The oldest and simplest hand layup technique was used for fabrication. The reinforced material such as mat, or woven roving was placed manually in the open mould, and then the resin was poured and sprayed on the reinforced material. After the completion of the first face, the rolling of the fiber was continued around the mandrel. The mold was left 24 hours to ensure its dryness completely, and then, the mold was removed from the tube.

Finally, the producing tube became ready for next process. Same procedure was used for hybrid tubes.



The rolling up of the fiber in the mandrel was carried out in 10 methods. The first four methods belongs to the natural fiber combination and the next 6 belongs to the hybrid fiber combination. 1. J1 + J2 + J3

2. B1+ B2 + B3 3. J1 + B1 + J2

4. B1 + J1 + B2
5. J1 + G1 + J2
6. B1 + G1 + B2
7. J1 + K1 + J2
8. B1 + K1 + B2
9. G1 + K1 + J1
10. G1 + K1 + B1

D. TESTING PROCEDURE:

The specimens were subjected to a quasi static load using a computer scale load 100kN to make crushing test at a speed of 15 mm/minute. All the specimens were crushed with crushing distance of 80 mm. During the crushing test for each specimen, photos were taken for all stages of crushing in order to indicate the failure modes that could happen.

After the testing was finished. The results were checked to find that which has the better crash worthiness properties among the natural and hybrid fiber.

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TEST REPORT

Customer: Mr. B. Aravind Kumar No: 22, Sri Sakthi Nagar, Mahabharatha Street, Annanur Chennai – 600 109.	Report No / Date	ML/31976A/1/Dt: 13 Feb 2018
	Your ref./ Date	Letter / Dt: 12 Feb 2018
	Our ref./ Date	YOCR: 31976A/Dt: 12 Feb 2018
	Nature of test	Compression Test.
	Test reference	Customer Specification
	Date of Testing	13 Feb 2018
	Sample Drawn By	Customer
	Sample Description	Test Specimen Qty: 7Nos

Compression Test:

Test Parameters	Observed Values						
	3 Layers of Banana Fiber	Banana, Glass, Kevlar Fiber	One Kevlar, 2 Banana Layer	One Glass, 2 Banana Layer	2 Kenav , One Kevlar	Banana, Kevlar, Banana	3 Layers of Kevlar
Gauge Thickness (mm)	7.32	6.23	6.82	7.39	5.01	6.36	5.38
Gauge Width (mm)	60.50	58.95	60.71	60.49	56.62	59.81	56.67
Original Cross Sectional Area (mm^2)	1722.95	1031.84	1154.63	1232.79	812.31	1067.96	866.89
Ultimate Tensile Load (kN)	24.94	33.88	22.35	24.55	29.32	30.63	31.79
Ultimate Tensile Strength (N/mm^2 or Mpa)	20.00	33.00	19.00	20.00	36.00	29.00	37.00

Verified by: ——— CONCLUDED ———

For MICROLAB

P. Selvakumar – Head Mechanical
Authorised Signatory