A Comparative Analysis on Energy Absorption Capabilities of Epoxy E-Glass and Epoxy Carbon Fibres

RAJASEKHAR SIVAPURAM*, HARI PRASADA REDDY YEDULA**, CHNADRA MOHANA REDDY BAGGIDI***

*(Department of Mechanical Engineering, QIS College of Engineering & Technology, Ongole-523272, Andhra Pradesh)

rajdme25@gmail.com

** (Professor of Mechanical Engineering, Annamacharya Institute of Technology & Science, Tirupati-517520, Andhra Pradesh)

prof.yhpr@gmail.com

*** (Department of Mechanical Engineering, JNTUA College of Engineering, Kalikiri-517234, Chittoor (Dist), Andhra Pradesh)

cmr_b.mech@jntua.ac.in

Abstract

In past few decades, many researchers have report on reducing impact on the passengers by making the automotive and aircraft structures become energy absorbing agents during the crash. Fibre composite materials have wide range applications than metals due to their light in weight, easy of fabrication and offer more strength while loading. Among all fibres glass and carbon fibres are effective for during loading for showing their strength, stiffness and specific energy absorption for given mass of material.In this present experimental investigation E-glass and carbon fibre composite tubes were taken to investigate the energy absorption properties composites. The fibres were manufactured by proper mixing of E-Glass and Carbon fibres with adding epoxy resin and k12 hardener by hand layup process.Quasi-static compressive loading has done on the composite tubes to determine the crash behavior of composite tubes. The results were shown that epoxy carbon fibers shown good results in 0.2% yield strength, tensile strength and more specific energy absorption capacities for a given mass of the material than glass fibre.

Key words: *E-Glass Fibre, Carbon Fibre, Epoxy Resin, K12 Hardener, Yield strength, Tensile Strength, Specific Energy Absorption Capacity.*

I. Introduction

Vehicles and aircraft structures design have become more challenging for designers to design structures during crash. The main concern on the structures is to produce high rate of energy absorption capabilities during the crash for reducing impact on the passengers. The one who is substitution for satisfying the crashworthiness characters are composite materials. Properties of the composite materials superior than ordinary materials due to their light in weight, easy of fabrication and offer more strength while loading.Moreover high design flexibility and wide variety of reinforcement types, orientation, various matrix materials and various manufacturing techniques for better improvement in mechanical properties.An important parameter for studying the energy absorption character is specific energy absorption; it is defined as the energy absorption during the crash per unit mass of the crushed material.

Melo,jose Daniel diniz [1] investigates the energy absorption properties of glass/polyester composites by taking the layups $[0/90]_n$ and $[+/- 45]_n$. the influence of cross section geometry,layup sequence and efficiency of trigger mechanism are examined. Overall the circular cross section of $[90]_n$ showed the highest energy absorption properties.javadmarzbanrad[2] reports on energy absorption properties of thin walled tubes with different geometric dimensions such as square,circular and elliptical tubes of steel and aluminium. The results declare among all sections elliptical crass section had more energy absorption and also increasing the thickness for smaller tubes had good energy absorption capabilities.oshkovar [3] made research on silky/epoxy composite square tubes for energy absorption and failure response. The more energy absorbed by the longest and thickest square tube and short length tubes performed for highest specific energy absorbing agents. In this present investigation epoxy e-glass and carbon fibers were manufactured in the form of hallow circular cross section by hand layup process and tested under quasi-static compressive loading conditions to reveal the energy absorption properties.

II. Experimental procedures

2.1. Fabrication of the composites

A total of 10 layers of e-glass/epoxy and carbon/epoxy were produced with a layup of [0/90]n to produce with nominal wall thickness of 5 mm. the raw materials were taken for samples preparation epoxy resin, e-glass and carbon fibres and k-12hardener. The samples are prepared by rolling woven carbon/e-glass fibers on to a mandrel by wet hand layup methodwere allowed to cure for 24h at ambient temperature. Thetest samples were machined according to the dimensions of 74mm external diameter with 64mm internal diameter and 50mm external diameter with 40mm internal diameter shown in fig 1 and fig2. The geometrical properties of the composites were displayed in the table 1. The samples were named with T-1 , T-2 for glass fibers and T-3,T-4 for carbon fibers.

T-1

T-2

Fig 1. Epoxy E-glass fiber test specimens

2.2. Crushing procedure

The samples were tested under quasi-static compression loading condition with the cross head speed of 10m/min using machine model Tue-Cn-400 universal testing machine. Thecompression loading setup utilized for the calculation of energy absorption properties of the composite tubes.

T-3

T-**4**

Fig 2. Epoxy carbon fiber test specimens

III. Results and discussion

The crash worthiness characteristics are calculated as follows:
The average crush load was calculated as, follows:

$$F_a=\frac{\int_0^s F.ds}{s} \qquad (1)$$

To get the SEA, the energy absorbed during the crush loading was divided by the mass of the material.

$$SEA=\frac{\int_0^s F.ds}{m} \qquad (2)$$

The experimental results are presented in the table 1. From the figures 3 and 4 we obtained the graphical representation of variation of values of initial peak load, average crush load, specific energy absorption during the crush. Average crush load was calculated from equation 1. To get the Sea,the energy absorbed during the crush loading was divided by the mass of the crushed material.

The initial peak load and average crush load for composites manufactured by e-glass/epoxy fibres is high for T-1 specimen respectively 96kn and 94.6kn compared to T-2 specimen of 54.78kn and 49.2kn. The crushing length of the T-2was 39.00 was more than T-1 sample (29.52).the load ratio was more for T-1 sample. But energy absorbed during the crush for the T-1 sample is 8640 more than T-2 sample of 4930. The specific energy absorption capacity for the sample T-1 was 34.56 j/g and T-2 was 30.81 j/g.

The samples T-3 and T-4 shown that smaller values of initial peak load, average crush load than T-1 and T-2 specimens it was shown in fig 3. Mass of the crushed material and energyabsorbed during the crush of Carbon fiber/epoxy shown poor results compared to glass fibre/epoxy for the same cross section.But the specific energy capacity of carbon fibers given good results than glass fibers. T-3
given 39.12 j/g more value than T-1 of 34.56 j/g. the sample T-4 given 43.02 j/g than T-2 of
39.12 j/g. Finally it is observed that for given mass of material larger cross section given more valuesin initial peak load, average crush loadand mass of the materialand energy

Table 1. Properties of composite specimens

Specimen	Material	Outside diameter (mm)	Inside diameter (mm)	Length (mm)	Cross section	Fiber configuration
T-1	EPOXY E-GLASS FIBER	74	64	90	CIRCULAR	$[0/90]_{10}$
T-2	EPOXY E-GLASS FIBER	50	40	90	CIRCULAR	$[0/90]_{10}$
T-3	EPOXY CARBON FIBER	74	64	90	CIRCULAR	$[0/90]_{10}$
T-4	EPOXY CARBON FIBER	50	40	90	CIRCULAR	$[0/90]_{10}$

Table 2. Energy absorption properties of composite tubes

Specimen	Initial peak load/kN	Average crush load/kN	Crush length/ mm	Load ratio	Mass of the crushed material/g	energy absorbed during the crushing/J	Specific energy absorption/J /g
T-1	96.0	94.6	29.52	1.01	250	8640	34.56
T-2	54.78	49.2	39.00	1.11	160	4930	30.81
T-3	65.2	64.3	14.20	1.01	150	5868	39.12

T-4	47.8	43.4	25.20	1.10	100	4302	43.02

absorbed during the crush in both E-Glass and Carbon fibre tubes. But larger cross section tubes failure to given good results inload ratio than smaller cross sections tubes. The results of sea of carbon fibers shown good results than glass fibers of any cross section it was shown in fig 4.

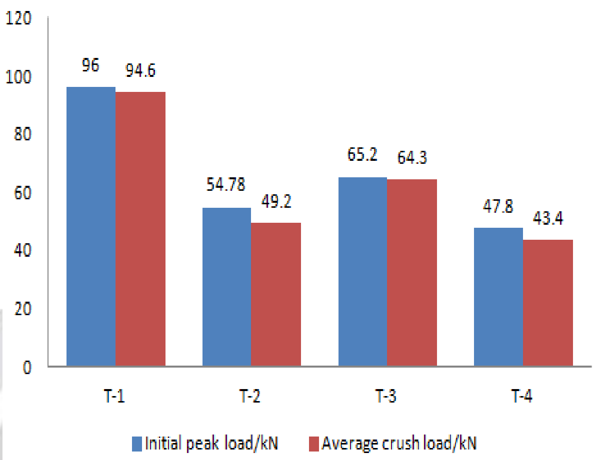

Fig 3.Peak and Average load characteristic for E-Glass and Carbon fibers

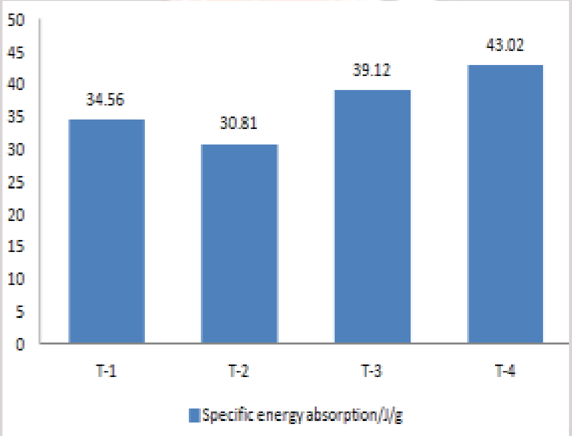

Fig 4. Specific Energy for E-Glass and Carbon fibers

IV. Conclusions

In this paper axial crushing of E-Glass/epoxy and Carbon/epoxy fiber tubes under quasi-static condition with compression loading was investigated. Based on the experimental results it was concluding that:

- Composites tubes weremanufactured with larger cross sections given more values in initial peak load and energy absorbed during the crush both in E-Glass fibers and Carbon fibers.
- But load ratio values are good in smaller cross section tubes of all the fibers.
- The specific energy absorbed during that was good in tubes of glass fibers of sample T-1 than sample T-2.
- Carbon fibers with small cross section tubes shown very best results than larger cross sections tubes. But for any cross section the values of sea was more for Carbon fiber tubes than E-Glass fiber tubes.

Scope for future work

It is suggested that the effect of manufacturing conditions on the specific energy absorption capacity and experimental investigation on failure mode of fibers during dynamic loading condition should be investigated.

Acknowledgement

I express my gratitude to my beloved professor's Dr. Y. Hariprasada Reddy and Dr. B. Chandra Mohana Reddy for their valuable information and suggestions.

References

[1]. MeloJose Daniel Diniz, Silva Andre Luiz Dos Santos, Energy Absorption Capability of Composite Tubes under Compression Load. 18th International Congress of Mechanical Engineering November 6-11, 2005, OuroPreto, MG.

[2]. JavadMarzbanrad, Mehdi Mehdikhanlo, Ashcan Saeedi Pour, An Energy Absorption Comparision of Square, Circular, And Elliptical Steel and Aluminium Tubes Under Impact Loading. Turkish J.Eng.Env.Sci.33 (2009), 159-166. Doi:10.3906 /Muh-0904-11.

[3]. Oshkovr, SiminAtallahi ; Taher, SiavashTalebi ; A.Eshkoor, Rahim ; Ariffin, Ahmad Kamal; Azhari,CheHusna, Energy Absorption And Failure Response of Silk/Epoxy Composite Square Tubes: Experimental. DOI. 10.1016/J.Compositesb.2011.08.019

[4]. M.Stamenovic, S.Putic,.Milovic, J.Palvovic-Krstic, Specific Energy Absorption Capacity of Glass-Polyester Composite Tubes Under Static Compressive Loading. ISSN 0543-5846. Metabk 50(03) 197-200 (2011).

[5]. Mamlis, A.G, Crashworthy Capability of Composite Material Structures. Composite Structures, Vol.37, Pp.109-134.

[6]. Thornton, Ph; Jeryan, Ra; Crash Energy Management in Composite Automotive Structures. International Journal of Impact Engineering, Vol.7, No.2, Pp.167-180.

[7]. Callus Pj, MouritzAp, Banister Mk, Leon Kh, Tensile Properties And Failure Mechanisms of 3d Woven Grp Composites. 1999; 30 (11): 1277-87 Compos AApplSci Manuf.