Drop Weight Impact Energy Absorption Capacity of Elastomer Filled Aluminium Tubes

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Abstract- *Examination of crashworthy structures has been an essential region of enthusiasm for some scientists for many years now. The journey for a superior vitality engrossing structure or a superior crashworthy structure has driven scientists to complete different examination strategies tentatively and furthermore by mimicking the attributes. E-glass fiber strengthened epoxy wrapped over aluminum tube has demonstrated to have better vitality engrossing abilities. This investigation endeavors to break down specific attributes of such half breed structures.*

This postulation looks at the properties regarding vitality assimilation of the above said tubes when certain parameters, for example, tubes filled with different shore number elastomers and tubes subjected to heat treatment.

The examination is done for different stages and mixes of the previously mentioned parameters, and the outcomes got are examined and goes for ideal arrangement of parameters for making the vitality retention of such half and half structures.

Keywords- Drop weight impact, Energy safeguards, Aluminium tubes, Load-displacement curves.

I. INTRODUCTION

Safety has been a huge worry in the region of plan for quite a while now Security regarding vehicles takes a gander at different regions while outlining one. One of these viewpoints is to have the capacity to withstand affect without making any mischief the tenants. This property can be accomplished by outlining vehicles comprising of crashworthy structures. Crash value of a structure is characterized as the capacity to retain the effect vitality and along these lines conveying the traveler compartment to rest without the tenant being subjected to high or sudden deceleration, which can cause genuine wounds. Progressive rot in the stack profile and controlled disappointment components are a portion of the properties through which crash value can be accomplished.

Vitality ingestion (SEA) which may change with the material. Particular vitality ingestion is the proportion of vitality assimilated to the unit mass of the material.

Many examines is being done by researchers and scientists everywhere throughout the world, in numerous enterprises so as to gain information on greatest measure of vitality that can be ingested for a particular misshaping of materials. For instance the disfigurement of autos is intended for a scope of mishap situations keeping in mind the end goal to keep up survivable volume with increasing speed levels, to stay away from human damage. In other down to earth circumstances, the most extreme measure of vitality, which can be ingested preceding a material failure tests are required.

1.1 Aluminum tubes as effect energy safeguards

Round tubes are utilized broadly as energy engrossing components, the primary fascination being their prepared accessibility in an extensive variety of measurements and materials and also the extensive variety of distortion modes which can be produced. Contingent on the method of misshaping, it is conceivable to get conduct extending from a low compel long stroke trademark to a high constrain - short stroke trademark from a similar tube.

Fundamentally tubes can be subjected to diametral (or sidelong) pressure or pivotal pressure. The horizontal pressure modes which create the moderately low compel long stroke twisting attributes have been looked into by Reid et al [1] and an especially effective variation of this mode has been portrayed by Reid et al. [2]. With respect to pivotal pressure, the tube might be subjected to pressure between two level plates or between a level plate and a formed kick the bucket. In the previous case, which has been considered by many creators, the tube distorts by dynamic locking in an asymmetric, concertina mode or in precious stone crease designs [3].

Strong et al. [4, 5] have inspected the conduct of square-segmented tubes gone ahead to a formed kick the bucket. Breaks are started at the corners and splits engender along the edges of the tube while the level strips so framed twist up as the pressure proceeds. It was watched that such a energy retaining gadget has a long stroke.

1.2 Aluminum tubes under axial pressure

The conduct of a pivotally compacted tube relies on upon the end apparatuses gave. For instance a tube might be settled at both its end; or it might be given basically bolstered conditions by putting the tubes in reasonable notches; or it might be compacted between two level plates; or it might be packed between two formed kick the bucket installations; and any blends of these are conceivable. Tubes smashed under pivotally connected deposits through two level plates demonstrate a dynamic plastic collapsing conduct. The end states of the tube just influence their conduct amid the initial segment of the squash uprooting.

One of the earliest analyses to be done on the buckling of the thin walled cylinders was presented by Alexander in 1960. The main objectives of Alexander's [6] work were to predict the necessary dimensions for cylindrical shell that were to be used as energy absorbers in the vertical fuel channels of nuclear reactors. He proposed a simple model of collapse, in which a general fold other than the one near the edge consisted of two straight-sided convolutions by virtue of the simultaneous formation of three fully plastic circumferential hinges. The following are the assumptions made in Alexander's model are as follows:

- The tube material was assumed to be rigid perfectly-plastic, hence ignoring all elastic and strain hardening effects.
- The deformation process was governed by the Von - Misses yield criterion.
- The value of the material yield stress in both tension and compression are equal.
- The material is deforming under plain strain conditions.
- The folds are formed in sequence one at a time and are either fully outward or fully inward with respect to the original tube wall.

II. A BRIEF LITERATURE REVIEW

Several review articles have been published in recent years, which provide a wealth of the published literature and some guidance for designers.

[1] Energy absorption and failure response of silk/epoxy composite square tubes: Experimental:
Silk is a fibrous protein with unique physical and mechanical properties. Silk with low density is a capable material to result a good value of specific energy absorption in composite structures compare with other synthetic fibers. The high value of elongation at failure caused silk composite square tubes performed a ductile behavior in compression tests.

The motivation of this work is rare information of silk fabric as a reinforcement material in composites structure. Results focused on silk/epoxy square tubes energy absorption capability and failure modes.

[1] Crashworthiness aspect of energy absorbers

Compressive tests were carried out on square cross-section specimens, consisting of 12 plies number of silk woven fabric and epoxy resin and various lengths (L), approximately equal to 50 mm with internal tube dimensions equal to 80X80 mm and radius (R) of curvature 5 mm at the tube corners. All specimens fabricated by wrapping of the fabric with resin over a mandrel. The thicknesses (t) of the tested tubes with 12 layersSilk/epoxy was equal to1.7 mm and different lengths (50 mm, 80 mm and 120 mm). Static axial compressive testes performed by INSTRON 5567 universal test machine with 30 kN loading capacity. The tests were in quasi-static conditions at constant cross head speed equal to 20 mm/min.

The most energy absorbed by the longest and thickest square tube which took longer time to reach the compaction zone. The other important parameter for an energy absorber is specific energy.

[2]Mechanical properties and energy absorption properties of aluminum foam-filled square tubes

The aluminum foams with the cross-section of 23mm×23 mm were prepared using a wire-cutting machine as the filling cores. In order to compare the influence of the height on the longitudinal compression deforming properties, two different heights of 40 and 60 mm were chosen. Aluminum tubes with outer cross-section dimensions of 25 mm×25 mm and wall thickness of 0.8 mm were prepared as the shell materials.

[3]Evaluation for Energy Absorbing Capacity of Concentric Aluminium Tubes Filled with Foam of Different Density

A two-component polyurethane (PU) consisted of polyol and 2,4-diphenylmethane dissociate (MDI). Both components are liquid at room temperature. Kenafbast fiber and recycled tire rubber particles were obtained from industries. The size of kenaf fibers and recycled tire rubber particles obtained was 80 mesh. Steel tubes used in this study were graded as BS 1387.

[4]Energy absorption capabilities of aluminium foam –filled square tube

ML 30 Al-alloy (Manufacture NALCO, India) contains 4.56 wt% Cu, 0.57 wt% Mg, 0.67 wt% Fe and 0.4 wt% Mn, 16.05 wt% Si, and rest is aluminium. LM 30+15% SiCp foam samples were manufacture through the melt route patented method by CSIR-AMPRI Bhopal. The porosity of aluminium foam varied from 78% to 92% and the cell sizes of aluminium foam varied from 0.5 to 3 mm. The aluminium foams with the dimension of 23x23x60 mm were prepared using a wire cutting machine as the filling cores. To compare the influence of the height on the axial compression deformation properties, two different heights of 60 and 80 mm were chosen. Aluminium tubes with outer cross-section dimensions of 25x25x60 mm3 and wall thickness of 0.80 mm were prepared as the shell materials. Aluminium foam cores and aluminium tubes were made up with an epoxy to get aluminium foam-filled square tubes. The data were the average value of six samples i.e. empty & foam-filled.

III. PREPARATION OF SPECIMENS:

The aluminum tubes which was procured which had an external distance across of 50.16 mm and inward breadth of 47.072 mm were made to experience different machining procedure such cutting, confronting and deburring and diminished to a standard size. After the machining procedure the tubes were of a stature 140 mm and weight of the void tube was observed to be 100.5 gm.

Some of these tubes were then strengthened, amid this they are set in a heater at a temperature of 4130C for aluminum for a hour time span and where left there to cool i.e., standardization was finished.

Fig 1:- Non annealed and annealed aluminium tube

IV. EXPERIMENTAL PROCEDURE

After the machining process, the exact amount of polymer required was calculated. In order to increases the rate of curing catalyst were used. For Polyester and Vinyl ester a liquid hardener called as Methyl Ethyl Ketone Peroxide (MEKP) was used. And for Polyurethane MOCA (PELLET) a solid hardener was used.

Depending on the volume of polymer 2% of Methyl ethyl ketone peroxide (MEKP) catalyst was added to each polyester and vinyl ester specimen and 20% of hardener was added to each of the Polyurethane specimen.

All the specimens were allowed to cure at room temperature after which the specimen is taken for next stage.

Fig 2:- Polyester and vinyl ester filled annealed aluminium tube.

Fig 3:- Shore 45, 60 and 70 Elastomer filled annealed aluminium tube.

4.1 Axial compression of metal tubes under impact loading conditions

The work involved breaking single test specimen by impact using the drop-weight test machine illustrated below. The input energy was determined by the weight of the steel disk (M) that was dropped on the particle from a level (h1). The drop height (h) is the difference between the final (h2) and the initial (h1) position of the steel weight. h2 varies as it depends on the residue after breakage.

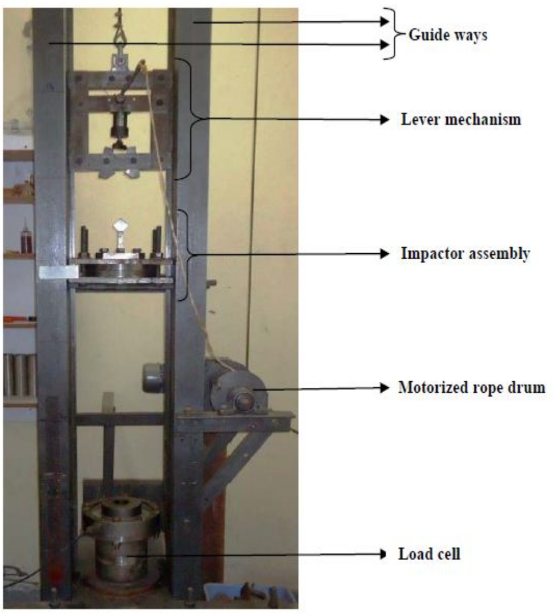

Fig 4:- Drop weight testing machine

TABLE 4.3:- Drop Weight Testing Machine Specifications:

SL NO	PARTICULARS	DETAILS
1	MAX. DROP HEIGHT	5.8 m
2	MAX. VELOCITY	10.77 m/s
3	DROP MASS	60-120 Kg
4	MAX. CAPACITY	6960 Joule
5	MAX. SIZE OF SPECIMEN	(200 X 200) mm

The crushing behavior was observed, the force-displacement and stress-strain curves were plotted.

The energy absorbing characteristics like crushing load, energy absorbed during the plastic deformation were recorded.

Theoretical values of the initial crushing load, energy absorbed, specific energy absorbed were calculated.

The theoretical and experimental values are compared results are tabulated.

The axial compression tests were carried out to obtain the energy absorption capacity of different materials using drop weight testing machine.

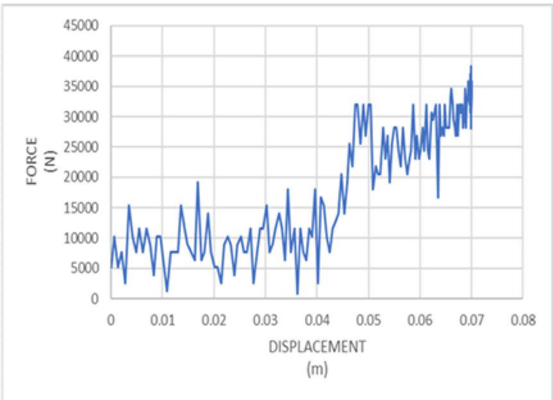

Fig 5:- Force vs. displacement curve of Annealed empty aluminium tube

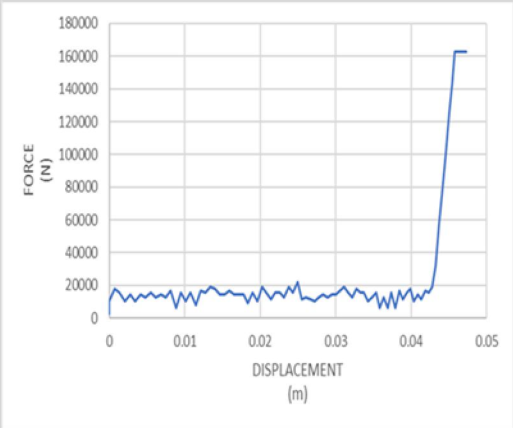

Fig 6:- Forcevs. displacement curve of vinyl ester filled aluminium tube

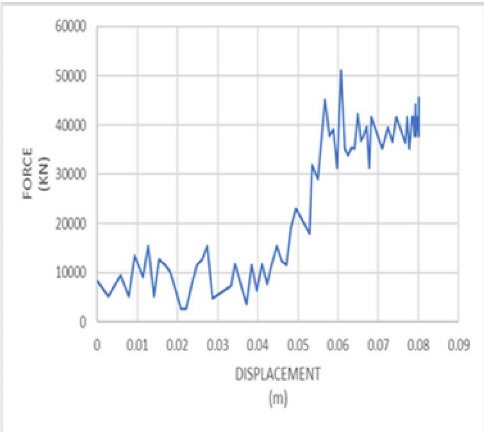

Fig 7:- Forcevs displacement curve of shore 45 polyurethane filled aluminium tube

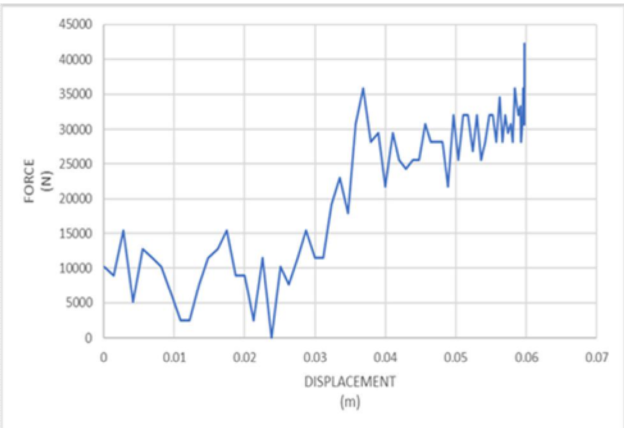

Fig 8:- Forcevs. displacement curve of shore 60 polyurethane filled aluminium tube

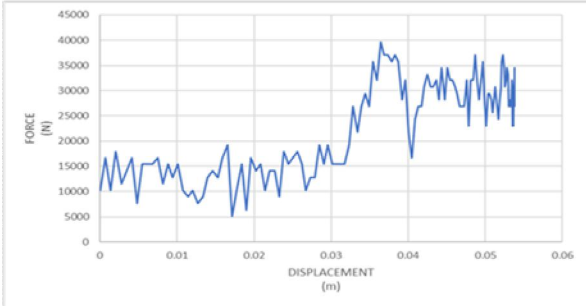

Fig 9:- Force vs. displacement curve of shore 70 polyurethane filled aluminium tube

Table 1:- Energy absorption capacity of different test specimen

TEST SPECIEMENS	TOTAL ENERGY ABSORBED UNDER IMPACT TEST (kJ)	SPECIFIC ENERGY ABSORBPTION (kJ/KG)	SPECIFIC ENERGY ABSORBPTION PER VOLUME (J/mm^3)
EMPTY ALUMINIUM TUBE (ANNEALED)	1.086	10.86	0.00392
SHORE A45 ELASTOMER FILLED TUBE	1.55	6.127	0.0056
SHORE A60 ELASTOMER FILLED TUBE	1.28	4.04	0.0046
SHORE A70 ELASTOMER FILLED TUBE	1.17	3.61	0.00423
VINYL ESTER FILLED TUBE	1.03	2.73	0.00373

V. DISCUSSIONS

Axial Compression tests were conducted and the load displacement curves were obtained for each of the test material. From these curves the energy absorbing capacities are determined by tracing the area under the average load line. In Impact testing it was observed that, Polyester and vinyl ester exhibited no deformation and drop hammer bounced back without any energy absorption. Whereas in polyurethane the energy absorbed was greater due to their elastic deformation.

VI. CONCLUSIONS

1. Experiments were conducted to understand the behavior of metal tubes under quasi-static axial compression load conditions.
2. The Aluminium tubes are tested for empty and filled conditions.
3. The plastic crushing of thin tubes resulted in Euler type of buckling. From this it can be concluded that the deformation modes depends on material properties of materials.
4. A comparison is made on the specific energy absorbing capacity and means crushing loads of Aluminium tubes.
5. The specific energy absorption capacity and mean crushing loads obtained during investigation can be used as data in designing the energy absorbers for various engineering applications like impact energy absorbers, crash pads.
6. Quasi-static test results can be taken to predict quasi-static behavior of the metal tubes under impact loading conditions.
7. Polymers such as Polyester and Vinyl ester materials cannot be used as crashworthy structures as they exhibit little or no deformation.
8. Elastomers such as Polyurethane is a better material to be used in crash structures compared to conventional empty tubes as it provides damping by absorbing the shock produced during impact.

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