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An overview on material and shape of crash box influence on the evaluation of the impact energy absorption capacity during a vehicle collision.

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ABSTRACT

Foldable encroachment is the absorbers of energy playing a very crucial role in the protection of automotive components being damaged during any dispute. Any sort of disputes between the two objects leads to damage to one of the objects or in some cases both of the objects. Such damages can be scratches, fractures, or minor cracks. The designers should know about the behavior of the object or the type of material and how it will react under encroachment events. Different forms of energy absorbers with foldable encroachment are formed because of these factors. For the last few years, numerous experiments have been carried out to develop such foldable encroachment energy absorbers. This paper illustrates the studies carried out on typical shapes and actions of foldable encroachment energy absorbers as well as its under encroachment behavior high axial strain. Literature is discussed in-depth focused on experiments and study of the impact of various parameters of the geometry on crushing behavior testing the behaviors of such energy absorbers. An energy absorber might have multiple formations like square tubes, circular tube, or frustums of pyramids and cones. Studies on dynamics of crushing, modes of deformation, the capacity of energy-absorbance, the impact on the maximum, and mean crushing stress are the factors used to detect the crushing actions of the energy absorber. The present work aims to cover significant data from previous research of such parameters showing the behavior. Although the maximum of the studies conducted on the metallic energy absorbers, the main focus is on including the studies, which made use of FML member, composite tube, FGT Tube, and the honeycomb plate in the form as a foldable encroachment energy absorber.

Keywords: *Foldable Encroachment Energy Absorber*

1. INTRODUCTION

Cars or any sort of vehicle today is considered under the fundamental needs of human civilization; hence customer safety has a significant role in this industry. Safety of passengers in an automobile is of great importance, which motivates the industry to enhance the designing of the cars. Improvements in the deigning of automobiles and improved conditions of highways have helped in reducing the number of injuries and death rates in almost every county, but still, the disputes related to the design are one of the primary causes of accidents. Focusing on an NHTSA report: "National Highway Traffic Safety Administration", the U.S. has recorded 30,900 deaths and more than 2,361,000 number of injuries in 2012, because of vehicle accidents. [1] Vehicle collisions are known worldwide as a significant health concern, but the problem in India is more significant. In India, almost 6,00,000 traffic collisions caused about 2,50,000 fatalities and three times the number of casualties, for the traffic incidents recorded for the years 2016 and 2017. Table 1 below demonstrates the magnitude of accidents and requirements of resolving this issue in India [2], reporting the comprehensive comparative cases for the years 2016-2017. The main cause for the crash was the conflict over façade automobiles, thus the production of vehicles of better safety value has to be granted with greater prominence. Data from the Death Analysis System of reporting [1] showed that despite the advancements n seat belt and airbag technology, there are still several death cases reported due to the design of automobiles. Hence Indian automobile companies should develop and design cars with higher reliability in case of accidents. This includes the usage of certain advanced innovations to increase the performance with the minimal weight of automobile crash tubes in automotive structures. This is achievable only with proper usage of materials and using an innovative designing.

Table 1: Number of accidents in the year 2014-2015 [2]

Parameter	2016	2017	% Change over the previous year
Accident Severity*	27.2	28.9	2.1
Persons injured	3,99,786	5,77,232	1.5
Total Accidents	4,70,300	6,10,532	2.6
Total number of deaths	1,50,000	1,46,143	4.7

Due to its cheaper price and strong plasticity features, steel is commonly used as an energy absorber. Weigh reduction of the automotive is important for improving the fuel efficiency and low emission of pollution by an automobile, such that the swing of magnesium (Mg) and aluminum (Al) alloy is used to replace traditional steel because of its good mechanical and low weight characteristics [3]. A number of reports have been conducted to test the worthiness performance during a substandard crash when a light-weight car is involved [4,5]. Ross and T. [6] researched that the probability of reduced casualty rates in crashes depends on a way in which car weights play an important role in road incidents and in utilizing innovative technologies to minimize weight without changing the car size for occupants' protection. “Insurance Institute for Highway Safety” in a report mentioned about the importance of poor crashworthiness due to vehicle weight by highlighting a dispute between sub-compact Yaris and mid-sized Toyota Camry [7]. The following explains in depth the idea of crashworthiness as well as the technical features of the energy absorber. It also includes literature evaluating the impact of various geometric parameters on energy absorbing capacity, modes of deformation, crushing mechanics, impact on mean and peak of thin-walled tubes concerning the crushing load.

2. ENCROACHMENT MECHANICS AND CRASHWORTHINESS

2.1 Mechanics of encroachment

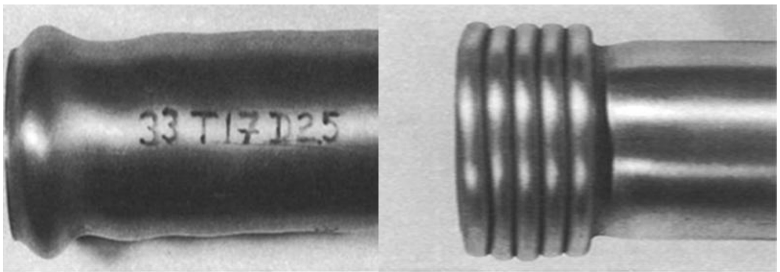
It is complicated to see the dynamic plastic deformation of the folding system than an analogous quasi-static deformed framework for a structure. The response of a system is distinct from the system under aquatic-static loading under the effects of Dynamic Loading. This is because of two physical fundamental processes, called the strain rate effect and inertia effect. A dynamic form of plastic collapses easily. The two physical factors impair the ability to absorb energy and crush the structural response of thin-walled energy.

2.2 Crashworthiness

Crashworthiness is the ability of the structure of a vehicle as well as its components to cope with the occupiers with no grievous injuries to the passengers or death when the car crashes. Presently this is becoming the primary figuring mechanism for vehicle design. The structure of an automobile must be capable of maximum absorption of encroachment energy owing lesser harm to the structure, or any harm to the people sitting in the automobile [9].

2.3 Inertia Effect

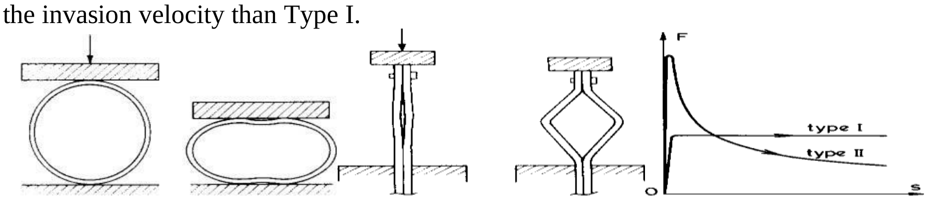
The thin wall structure of the tube, when subjected to the quasi-static type of loading, is slow enough for the effects of inertia to have little impact on the structure’s response to crushing, where on the other hand when the tube is subjected under axial-dynamic loading the effect of inertia will affect the response of crush. The final deformation shape relies on the structural loading that is if this is subjected under dynamic axial or Quasi-static loading. This deformed thin-walled structure of the circular tube under dynamic axial or Quasi-static loading is described in figure 1 below. Normally the progressive buckling of quasi-static type helps in developing encroachment of lower velocities, and the dynamic type helps in developing higher velocity encroachments. [10].



(a) Under dynamic loading (b) Under quasi-static loading

Fig. 1: Final circular tube deformation

The two structures which absorb energy by plastic deformation were studied by English and Calla Dine [11]. The type of static load-deflection curve defined these frameworks. The static load-deflection curve of type-I was comparatively “flopped” while the type-II curve had “steeply dropping” curve, as seen in figure 2 (c). Type-II was noticed by their analysis that the configuration is highly susceptible to the invasion velocity than Type I.



(a) Type I (b)Type II (c) Load-deflection curve

Fig. 2: Structures Types

2.4 Strain rate sensitivity

The dynamic loading material properties vary for the different corresponding quasi-static characteristics [15]. The material's behavior on stress-strain is responsive to the changing loading rate [16]. The plastic flow of different products, according to Lu and Yu [8], is sensitive to strain rates, while increasing the yield stress. The system is reinforced by the rise of the stress intensity, which is not desirable for vehicle crash energy absorbers [15]. The impact on the structure's reaction is important for the results of the material sensitivity to stress, such that sensitive material strain rate is taken into account [9]. The average strain rate is equation presented in Table 2 as established by Abramowicz and Jones [17]. The relationship presented by Cowper and Symonds [18] needs just two constants from the test studies on the substance in question. In the numerical and vertical studies [19], this equation is widely used.

Table 2: Average Strain Rate Equation [17].

Mode of deformation	Equation
Concertina Mode	$\varepsilon = \frac{V}{2D\left\{0.86-0.568\sqrt{\frac{t}{D}}\right\}}$ (a)
Diamond Mode	$\varepsilon = \frac{0.74V}{D}$ (2)

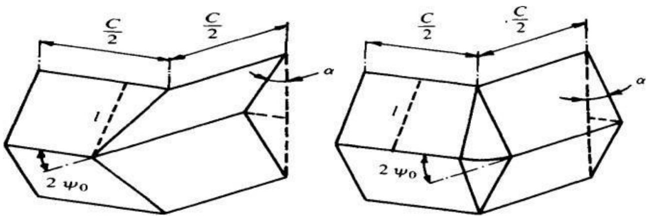
Where impact velocity is given by V.

The following equation is the Cowper-Symonds equation, depicting better agreement with the experimental values available for different metals.

$$\varepsilon_p = D\left\{\left(\frac{\sigma_d}{\sigma_s}\right) - 1\right\}^q (3)$$

2.5 Thin square tubes

Abramowicz and Wierzbicki [15] came up with the first-ever theoretical model for statically buckling the square shape tubes. Figure 4 demonstrates two basic elements of collapse. This type of geometry was used by the authors for examining the static progressive mechanism. In another research conducted by them, the same type of collapsing elements was used for studying the progressive and dynamic buckling in square tubes. Hough the two collapse elements, the authors predicted that there can be 4 types of deformations two asymmetric mixed modes, one extensional mode; and one symmetric mode. Additionally, come up with a theoretical equation given in table 4 to test the prediction criteria for Men Crushing Load.



(a) **Type-I** **(b)Type-II**

Fig. 3: Collapse elements

Table 3: Mean Crushing Load equations.

Mode of deformation	Theoretical Estimate from
Axisymmetric [20]	$F_m = CYh^{1.5}\sqrt{D}$ (4)
Non-Axisymmetric [21]	$F_m = Yh(10.5h + 0.38D)$ (5)

Where, D Diameter of the tube, h thickness of the tube, Y= yield strength, C= constant

Table 4: Mean Crushing Load equations

Deformation	Prediction Criteria	Equation
Symmetric	$C/_H > 40.08$	$\frac{F_m}{M_o} = 38.12(C/_H)^{1/3}$ (6)
Extensional	$C/_H > 40.08$	$\frac{F_m}{M_o} = 32.64(C/_H)^{1/2} + 8.16$ (7)
Asymmetric Mixed A	-	$\frac{F_m}{M_o} = 33.58(C/_H)^{1/3} + 2.92(C/_H)^{2/3} + 2$ (8)
Asymmetric Mixed B	$7.5 \le C/_H \le 40.08$	$\frac{F_m}{M_o} = 33.54(C/_H)^{1/3} + 1.65(C/_H)^{2/3} + 1$ (9)

Where H = Mean Thickness, C = Mean Width, M_o= moment of plastic wall per unit length

(a) Symmetric **(b) Extensional** **(c)Asymmetric mixed**

Fig. 4: Square tubes Deformation modes

3. ENERGY ABSORBERS

An energy absorber is the device that turns energy into other form of energy. This resultant energy is reversible either as the energy of elastic strain in the solids and for fluids the pressure energy and irreversible like solid deformation of the plastic [25]. As crash frames, a connection portion between the bumper and front cross chassis portion is often linked with the Foldable energy absorber. In popular literature, there are several foldable energies absorbers, one of the primarily sued absorbers can be defined as:

3.1 Thin metallic absorber

Thin tubes were the oldest and most popular type of absorbers of energy. This kind of absorber is built to gradually weaken through the regulated absorption of full intrusion energy [8]. The transition of kinetic energy into elastic strain energy depends on certain variables such as material properties, tube geometry, as well as the patterns of deformation. Jones [9] in his research studied that due to their lower expense, higher capacity of absorbing energy, and simplicity, the thin tubes are more desirable and fitting as energy absorbers. When subjected to axial compression stress, a thin-walled tube may be formed either in a diamond (non-axisymmetric buckle) or concertina (axisymmetric buckle). The concert in deformation has been shown by Jones [9] to be the most effective mode of energy absorption.

4. CONCLUSION

The objective of this review was to present information about the experiments conducted in metallic foldable absorbers of energy. The paper was conducted by first detailing how a lighter vehicle is formed and how it can affect the safety of a human being during the encroachment time and the significance of crashworthiness in cars. The present study also highlights all commonly used shapes of foldable encroachment absorbers of energy as well as its behavioral aspects under the dynamic or static axial compression. In addition to this the different effects of changing the geometrical features like length, cross-sectional dimensions, thickness, as well as the semi-apical angle for pyramids or cones on the modes of deformation, crushing mechanics, the capacity of energy absorbance, the impact of mean and peak crushing load were also discussed.

5. REFERENCES

[1] NHTSA 2012 Traffic Safety Facts, 2010 vol DOTHS 811
[2] 2015 Road Accidents in India Government of India
[3] Cole G Sand Sherman AM 1995 Lightweight materials for automotive applications Materials Characterization 35 3-9.
[4] Wang X and Kockelman KM 2005Transportation Research 195–204.
[5] Ross Mand Wenzel T 2001 Losing weight to save lives: Are view of the role of automobile weight and size in a traffic death.
[6] Insurance Institute for Highway Safety 2009 Status Report-Car Size and Weight Are Crucial Title 44.
[7] Lu Gand Yu T 2003 Energy Absorption of Structures and Materials Wood head Publishing Ltd.
[8] Jones N 2003 Structural Encroachment Cambridge University Press.
[9] Karagiozova Dand Jones N 2000 International Journal of Solids and Structures 372005–34.
[10] Calladine C Rand English R W 1984 International Journal of Mechanical Sciences 26689–701.
[11] Reddy T Y, Reid S Rand Barr R 1991 International Journal of Encroachment Engineering 11463–80.
[12] Karagiozova Dand Jones N 2004 International Journal of Encroachment Engineering 30167–92.
[13] Harrigan J 1999 International Journal of Encroachment Engineering 22955–79.
[14] Jones N 2016 Recent Studies on the Dynamic Plastic Behavior Structures 4295–115.
[15] Reid S Rand Harrigan J J 1998 International Journal of Mechanical Sciences 40263–80.
[16] Abramowicz Wand Jones N 1984 International Journal of Encroachment Engineering 2263–81.
[17] Symonds PS 1965 A S M E 106–24.

