VEHICLE CRASH BOX ANALYSIS OF IFFERENT SHAPES SUBJECTED TO IMPAC LOADING FOR MINIMUM DEFLECTION USING ANSYS

A. S. Shaikh[1], Dr. B. R. Borkar[2], Prof. V. B. Shinde[3],

[1] PG Student, Production Engineering, AVCOE, Sangamner
[2] Assistant Professor, Production Engineering, AVCOE, Sangamner
[3] Assistant Professor, Production Engineering, AVCOE, Sangamner

ABSTRACT

In world today every vehicle manufacturer is in the race of providing more and more safety to the passengers that leads to the development of heavy and costly equipment and material. One of them is providing Crash box to the vehicle which is generally located at the front bumper. The function of which is to safeguard the passenger by absorbing kinetic energy of collision and self-deformation. It is found that for maximum safety the deformation should be small and the energy absorption is more. Hence by changing shape and size of crash box the properties can be varied as required. Therefore by considering the effect of shape the Author proposed a work on vehicle crash box analysis of different shapes such as circular, square, rectangular and hexagonal of same volume using ANSYS and the optimum crash box shape is proposed which has a comparatively small deformation for the same impact loading condition. The hexagonal crash box absorbs about 50% more energy than the existing crash box. Hexagonal crash box gives 16% less deformation compare to existing crash box and elastic strain is nearly twice that of existing crash box.

Keyword: - *Crash box[1], Impact test[2], Energy absoption[3], ANSYS[4].*

---

1. INTRODUCTION

The crash boxes are the main load carrying members of the automotive structures. They are particularly designed for the absorption of the energy during the impact. There are some studies reported in the literature on the impact behaviour of crash boxes. In one of them, the impact analysis of thin walled tubes with square and circular cross sections is achieved using LS-DYNA finite element software and the results are compared with the experimental and theoretical results.[1] Thin walled beams are widely used as frontal crash absorbers in automotive chassis design. These beams are specifically designed to absorb high amounts of energy during a crash to ensure passenger cabin integrity and consequently passenger safety. Regulatory authorities such as NCAP have imposed stringent testing criteria that must be passed before a vehicle is declared roadworthy. Consequently, a good crash absorber design becomes desirable. Weight reduction is also important for the vehicle performance. Therefore, the collapse modes, buckle wavelengths and optimal triggers are studied and optimized extensively by designers by using impact testing techniques and, more recently, by FEM simulations.[2] Steel sheets of relatively high strength are currently used in automotive industry, to enhance the energy absorption of components like a crash box. The task of this kind of structure is to absorb a high energy during an accident, mainly in order to assure security of passengers by limiting the maximum deceleration level. Therefore, the structure must deform by a process of collapse and sequential folding during plastic deformation.[4]

The crash box located between bumper and side rails protects passengers and expensive vehicle components by absorbing initial kinetic energy in a frontal vehicle crash event by ensuring a low plastic flow stress level on the auto-body frame. The performance of the crash box can be evaluated on the basis of the Research Council for Automobile Repairs (RCAR) regulations. Numerous previous works have attempted to determine the cross section shape of the crash box by experimental and numerical analyses. They considered rectangular, octahedral, and hexagonal cross sections. A rectangular cross section showed the best crashworthiness in a full car model crash test involving a bumper, crash boxes, front side members, and sub-frames. The reduced mean width of hexagonal and octahedral cross sections caused torsion and global buckling collapse behavior. Therefore, in this work, we focus on a rectangular cross section beam for crash box application.[3]

From literature it is observed that very less work has been carried out on different shapes of crash boxes design is the main load carrying members of the automotive structures. In this study crash box of ford car was studied. So in this study four different shapes circle, rectangle, hexagon, square are manufactured in local industry. The material considered for crash box was mild steel and dimensions of crash box were kept same as that of the FORD crash box. After manufacturing four crash boxes it was tested on drop weight impact tester. In this work modeling and analysis was done by using ANSYS software. Finally the experimental results were compared with the software results.

2. EXPERIMENTAL METHODOLOGY

2.1 Impact test

In this experimental work test was done on especially manufactured machine by SF engineering solution Nashik. The impact testing machine having a capacity of mass 800 kg and height of 12 m and velocity up to 15 m/s which generate similar energy as that of vehicle impact on another for same K.E.=P.E. In this work we have taken m=800kg, h=12m, with some initial velocity. Test specimens are kept between two plates. This test was done on four different (square, rectangle, hexagon and circular) shapes of crash box. The experimental result is in the form of deformation and energy absorption and elastic strain. Figure 1 shows the photograph of impact test machine set up.

Fig -1: The impact test setup

Different shapes of (square, rectangular, circular and hexagonal) crash box were prepared from mild steel material. The actual photograph of different crash box is as shown in Figure 2.

Fig -2: Different Shapes of Crash Box before Impact test

Figure 4, 5, 6 & 7 shows that the effects of impact test on different shapes of crash box. From testing it is observed that hexagonal crash box gives best result as compared to other crash box.

Fig -3: Square Crash Box after Impact test

Fig -4: Rectangular Crash Box after Impact test

Fig -5: Circular Crash Box after Impact test

Fig -6: Hexagonal Crash Box after Impact test

3. RESULT & DISCUSSION

3.1 Experimental result of Impact test

The all experiments were performed on impact test machine and the result of this test is as shown in Table 1.

Table -1: Experimental result of impact test

Shape of crash box	Deformation (mm)	Elastic strain (mm/m)	Energy absorption(J
Square	80	34.34	4510
Rectangle	81	27.10	3208
Circle	74	54.30	5890
Hexagonal	**70**	**65.64**	**6711**

3.2 ANSYS Results

In this study analysis of crash box is done by CATIA V5 and FEA software ANSYS 12.0, geometric modeling is done in CATIA V5 and analysis of different shapes is done in ANSYS 12.0 software. Table 2 shows that the ANSYS result for different shapes.

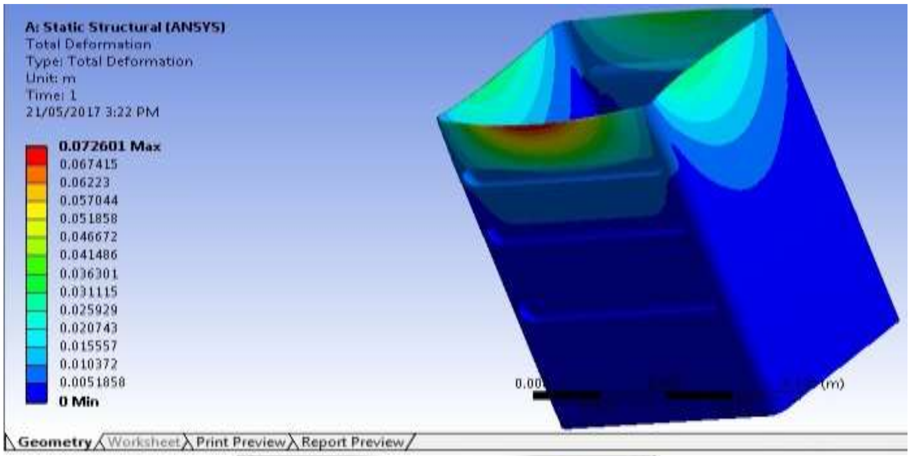

Fig -7: Deformation of Square Crash Box.

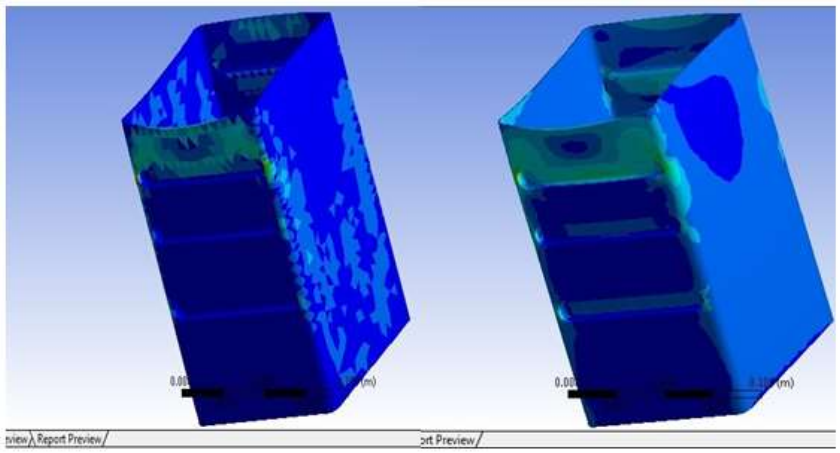

Fig -8: Elastic strain and energy absorption for square crash box.

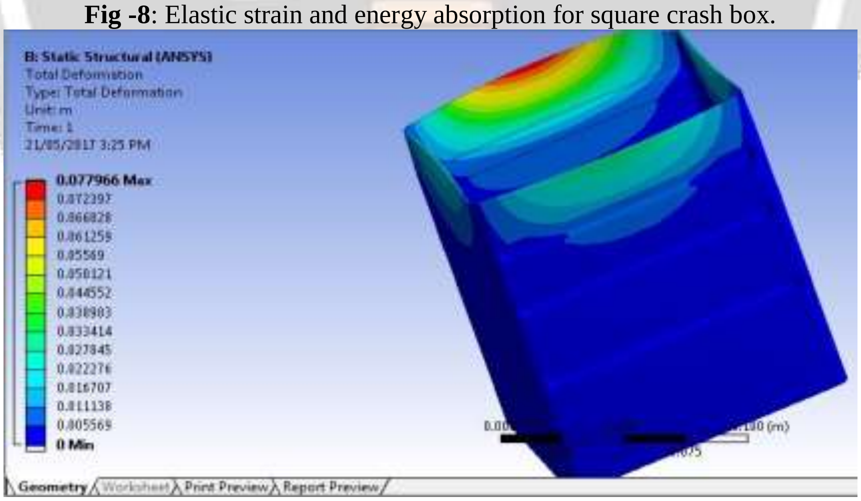

Fig -9: Deformation of Rectangular Crash Box.

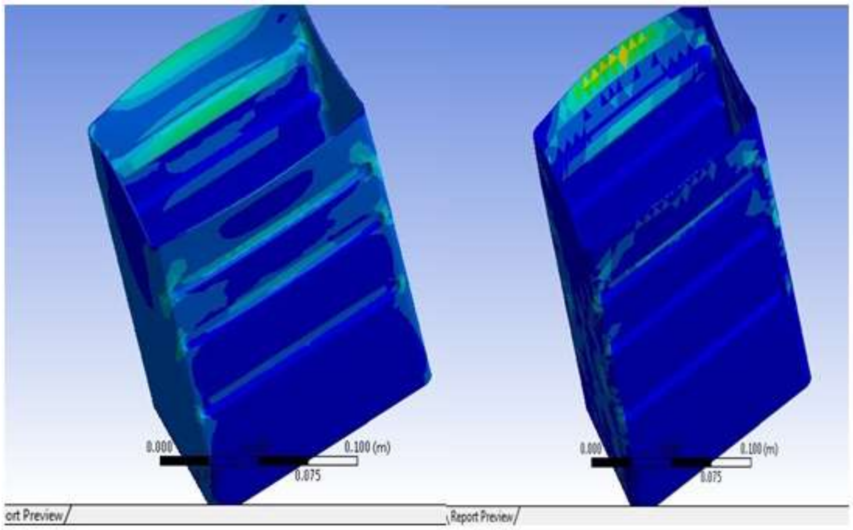

Fig -10: Elastic strain and energy absorption for rectangular crash box.

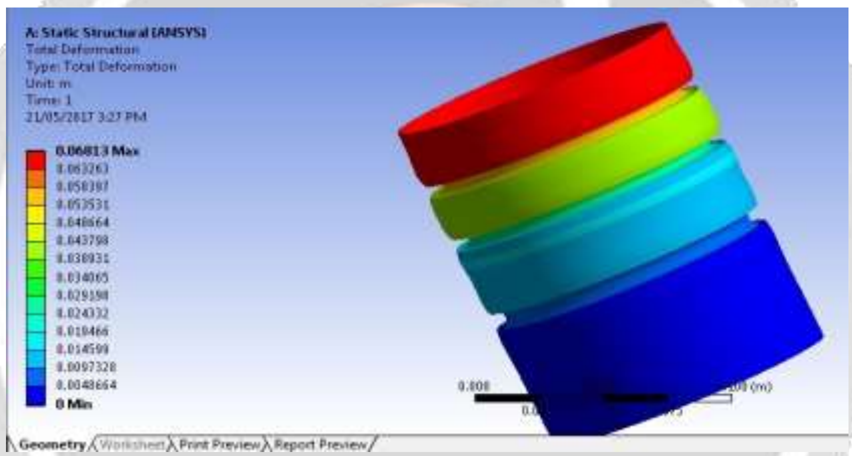

Fig -11: Deformation of Circular Crash Box.

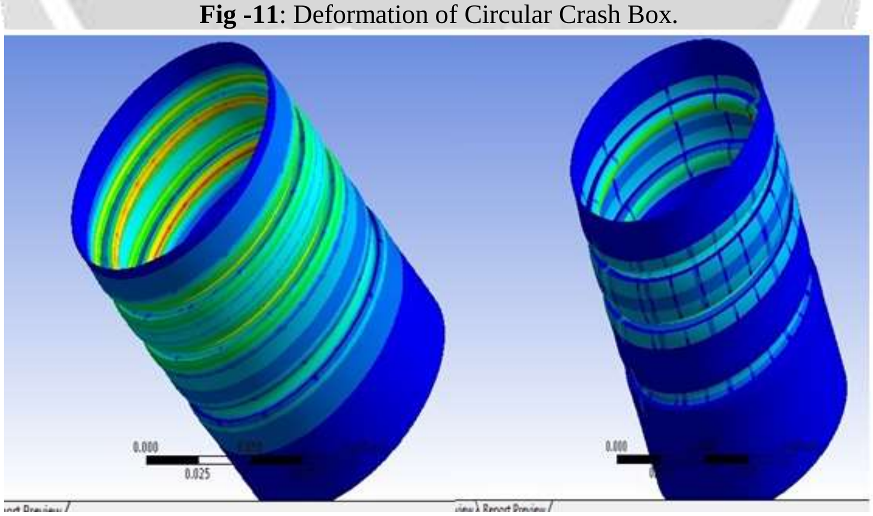

Fig -12: Elastic strain and energy absorption for circular crash box.

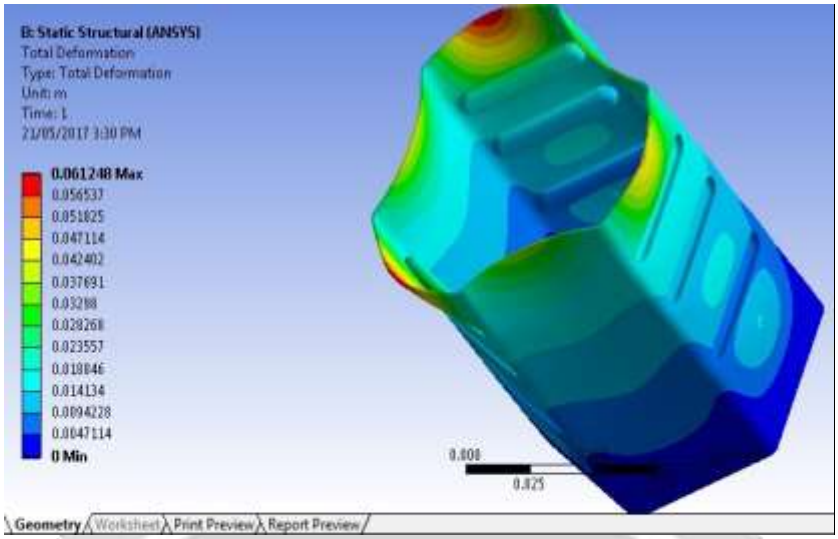

Fig -13: Deformation of Hexagonal Crash Box.

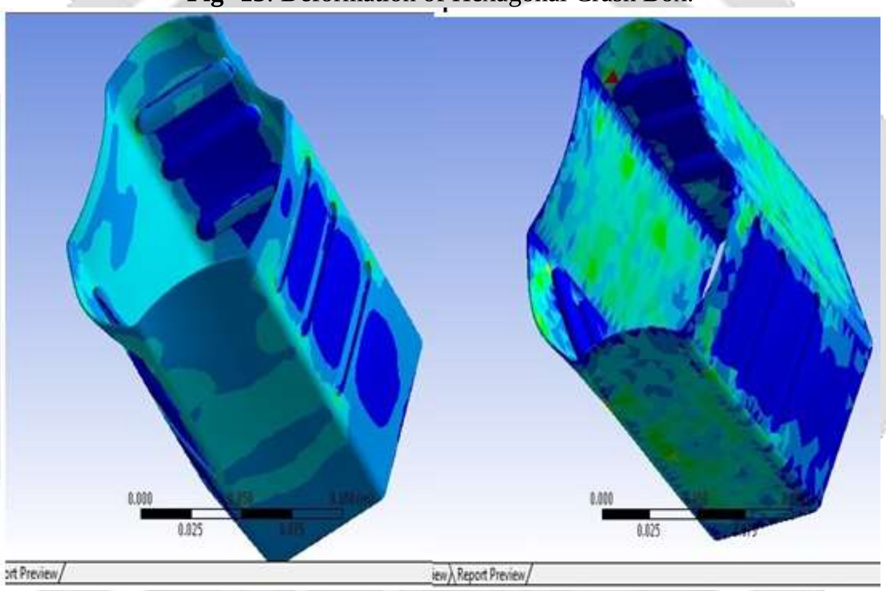

Fig -14: Elastic strain and energy absorption for Hexagonal crash box.

Table -2: ANSYS results

Shape of crash box	Deformation (mm)	Elastic strain (mm/m)	Energy absorption (J)
Square	72	32.53	4218
Rectangle	77	24.17	3535
Circle	68	54.66	5320
Hexagonal	**61.2**	**61.64**	**6533**

From the ANSYS results we can say that hexagonal shape crash box it gives minimum deformation of 61.2mm, maximum elastic strain 61.64 mm/m and energy absorption is 6533 J. for same load of force 60062.5 N.

3.2 Comparison of experimental & ANSYS Results

Table -3: Comparison of Experimental & ANSYS results

	Experimental Result			ANSYS Result		
Shape of crash bo:	Deformation (mm)	Elastic strain (mm/m)	Energy absorptio (J)	Deformation (mm)	Elastic strain (mm/m)	:nergy absorpti (J)
Square	80	34.34	4510	72	32.53	4218
Rectangle	81	27.10	3208	77	24.17	3535
Circle	74	54.30	5890	68	54.66	5320
Hexagonal	**70**	**65.64**	**6711**	**61.2**	**61.64**	**6533**

4. CONCLUSIONS

In this experimental work four different shapes square, rectangle, circle & hexagon were investigated for crash box. The following conclusions are drawn:

1) Out of these four shapes of crash box, hexagonal shape crash box has energy absorption 50% more than that of FORD Crash box, which is under consideration.
2) It also observed that hexagonal crash box shows 16 % less deformation than that of FORD crash box, which is under consideration.
3) It also shows that of hexagonal crash box gives elastic strain nearly twice than that of FORD crash box, which is under consideration.
4) So from this study it can be concluded that different shapes of crash box showing different results and in this study hexagonal shape crash box is found to be better.

5. REFERENCES

[1] Ince F., Tuerkman H.S., Mecitoglu Z. Uludag N., Durgun I., Altinok E. and Orenel H. Experimental and numerical study on impact behavior of box. Procedia Engineering 10 (2011) 1736–1741.
[2] Qureshi O.M. and Bertocchi E. Crash behavior of thin walled box beams with complex sinusoidal relief pattern. Thin-Walled Structures 53 (2012) 217–223.
[3] Kim H.C., Shin D.K. Lee J.J. and Kwon J.B. Crashworthiness of aluminum /CFRP square hollow section beam under axial impact loading for crash box application. Composite Structures 112 (2014) 1–10.
[4] Rusinek A., Zaera R., Forquin P. and Klepaczko R. Effect of plastic deformation and boundary condition combined with elastic wave propagation on collapse site of crash box. Thin-Walled Structures 46 (2008) 1143–1163.
[5] Toksoy A.K. and Guden M. 2010. Partial Al foam filling of commercial 1050H14 al crash box: the effect of box column thickness and foam relative density on energy absorption. Thin-Walled Structures 48 (2010) 482–494.
[6] Boria S., Obradovic J. and Belingardi G. Experimental and numerical investigation on impact behavior of composite frontal crash structure. Composites part vol. B 79, (2015)20-27.
[7] Li N., Fang H., Zhang C., Gutowski M., Palta E. and Wang Q. Numerical study of occupant responses and injuries in vehicular crashes into roadside barriers based on finite element simulation. advances of engineering Software. vol. 90, (2015) 22.40.
[8] Shrivastav V. and Dr.Telang A. Optimization of impact attenuator design using Finite Element Method for enhanced vehicle safety during collision. International journal of science and research, volume 5. (2015) 50-73