VEHICLE CRASH BOX ANALYSIS OF DIFFERENT SHAPES SUBJECTED TO IMPACT LOADING FOR MINIMUM DEFLECTION USING ANSYS

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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: - *ANSYS, Collision, Crash box, Energy absorption, Impact test*

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]

Fig - crash box [6]

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 andnumerical 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

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.

2.1 TYPES OF CRASH BOX:

1) Carbon Fiber Crash Box:

Carbon fiber reinforced polymer which are extremely strong and light fiber reinforced plastic which contain carbon fiber. Polymers that are usually used for binding are mainly thermo set resin. Epoxy is one of the thermo set resins. Sometimes in some cases other thermoplastic is also used. Such polymers are polyester or nylon. The required strength and rigidity of a carbon fiber reinforced polymer is obtained from reinforcement which is gives stress and elastic modulus accordingly. Unlike isotropic material like steel and aluminum CFRP has a directional property.

Fig. circular carbon fiber crash box [7]

CFRPs demonstrate excellent corrosion resistance; the effect of moisture at wide range of temperatures can lead to the degradation of mechanical properties of CFRP, particularly at matrix-fiber interface. Carbon fiber crash box are light weight compare to other conventional crash box made of steel. Carbon fiber normally used in super cars in normally, but now many car makers and modifiers are starting to use it for replacement body parts on everyday cars. [7]

2) Aluminum Honeycomb Sandwich Crash Box:

As from the name we know that it has geometry of honeycomb which minimizes amount of material used. Due to this it causes to lower its cost and weight. The aluminum honeycomb crash box is produced by expansion process. This type of construction consists of two thin facing layers separated by core material.

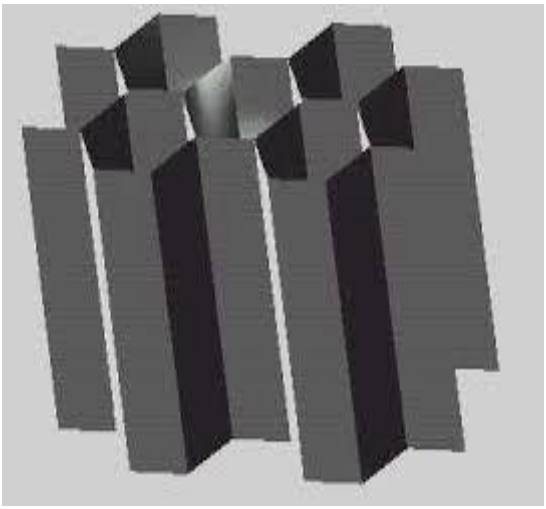

Fig. Structure of honeycomb crash box [7]

The aluminum honeycomb panel provides light weight, high rigidity and high structural stability. [7]

3) Steel Crash Box:

Steel front crash box mostly used in off road vehicles which has coating to influence the corrosion life of crash box. Steel is often e-coated and then printed and powder coated. Steel crash box is made up of a bare steel and then e-coated and then powder coated. Steel crash box are coated with zinc which improves the life of steel by discouraging or preventing corrosion. In past steel crash box was very thick to which it increases the weight. Now days because of new technology gauge of steel decreases and its strength increases. [7]

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Fig. steel crash box [7]

4) Metal Foam Crash Box:

The metal foam has cellular structure which consists of a solid metal as well as it has pores which makes it an ultra-light material. The aluminum and its alloy have low density due to which it is used as metal foam. Crash box made up of metal foam possess high compressive strength. Generally there are two types of foam open and close type. In automotive industry for making of crash box mostly closed type is used which provides optimal energy absorption. Many automakers make use of aluminum foam crash box which is placed between impact beam front rails of car. During collision at low speed of about 15km/hr. they deform and absorb all energy thus protecting all valuable parts of front of the car frame. [7]

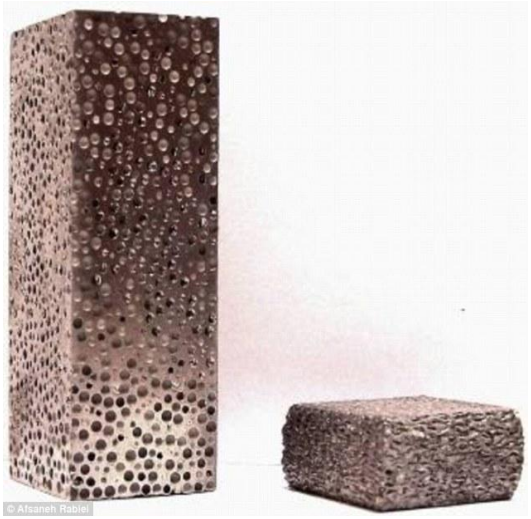

Fig. structure of metal foam crash box [7]

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

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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.

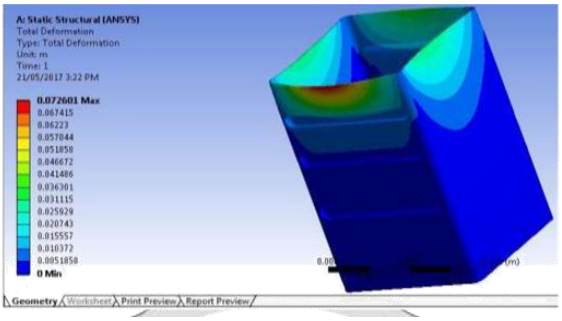

Fig -7: Deformation of Square Crash Box.

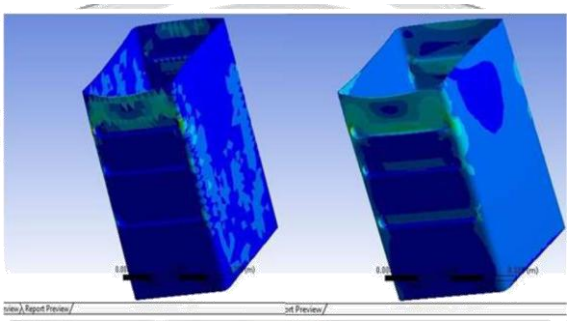

Fig -8: Elastic strain and energy absorption for square crash box.

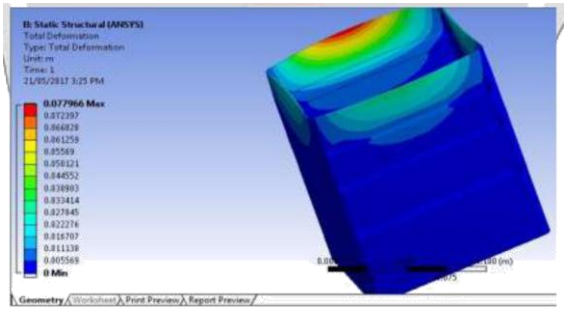

Fig -9: Deformation of Rectangular Crash Box.

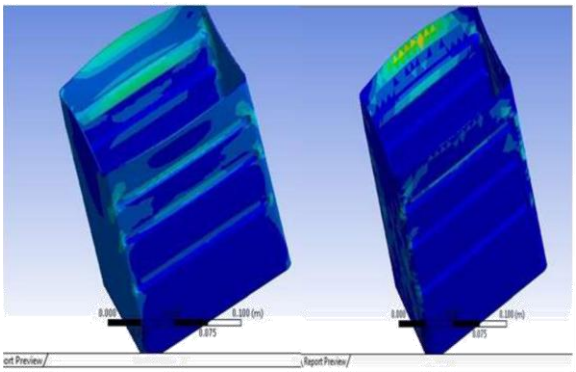

Fig -10: Elastic strain and energy absorption for rectangular crash box.

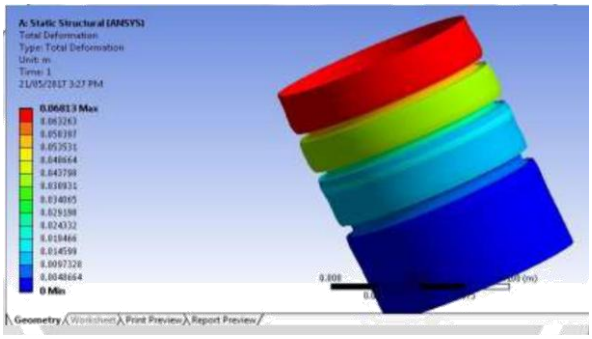

Fig -11: Deformation of Circular Crash Box.

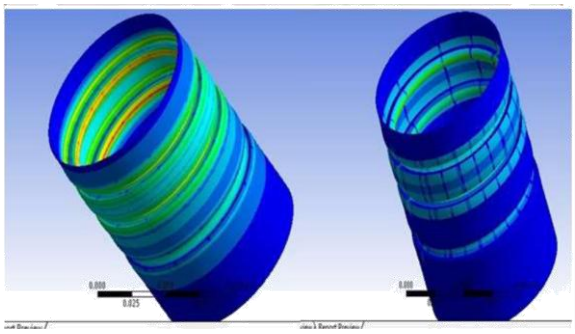

Fig -12: Elastic strain and energy absorption for circular crash box.

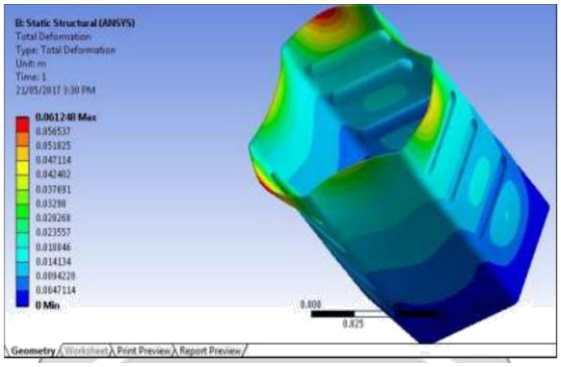

Fig -13: Deformation of Hexagonal Crash Box.

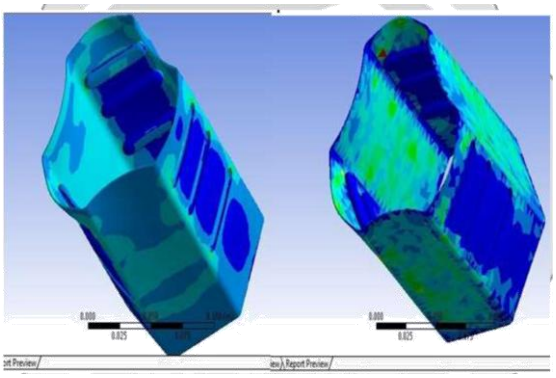

Fig -14: Elastic strain and energy absorption for Hexagonal crash box.

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.

Table -3: Comparison of Experimental & ANSYS results

	Experimental Result			**ANSYS Result**		
Shape of crash bo	Defor mation (mm)	Elastic strain (mm/m)	Energy absorptio (J)	Defor mation (mm)	Elastic strain (mm/m)	nergy absorpti (J)
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Circle	74	54.30	5890	68	54.66	5320
Hexagonal	**70**	**65.64**	**6711**	**61.2**	**61.64**	**6533**

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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.

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Custom Tool Development for Bearing Modeling in CATIA

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ABSTRACT

Today's world is a customer driven world. To remain in the market, one has to continuously innovate the product. Also, it is very important to enhance the productivity. This can be done by reducing the lead from design to manufacturing. Hence in order to reduce the lead time from design to manufacturing, different companies make the use of various CAD/CAM/CAE software, which are available in the market. Also, scientists, engineers and people from various areas are using CAD/CAM/CAE as a tool for completing various tasks. This CAD/CAM software available in the market are general purpose software that means this software are not developed for particular user or for particular task. The vendors of these software try to cover all the required applications of the industries through their modules. However, there are users who require the software for particular application. This can be done by molding the software for particular application. This molding of the software for a particular application to suit the requirement of the customer is called as customization of the CAD software. CATIA is high-end software. Various industries are using this to perform the task of solid modeling, assembly modeling and drafting of the various engineering components.

Bearing is a component used in various industries like punching machines, shearing machines, riveting machines, crushers etc. there are various types of bearing used in industries. The designer has to create the solid model as per the requirement of the customer, so we can customize CATIA for automated solid modeling of these bearing. Another aspect of customization is to integrate the design data with the other departments like sales. We can increase the domain of the user of this customized software. After customization, the work is compared with the situation of before and after customization through productivity enhancement table. This comparison reveals the importance of customization.

Keywords: *CATIA,CATScript, VBScript, MACRO, VBA*

1. INTRODUCTION

In today's world where innovation or change is always constant, time has emerged as the single most important factor for competitive success. Rising customer demands and immense global competition are forcing the engineering and consumer product companies to continuously seek ways to compress the lead-time from conceptual stage to market. In case of a new product, this could mean the difference between the assumed growth and doubtful survival. In order to increase productivity, it is necessary to reduce time for the development of product. The new trends of technology use computer as an unavoidable tool in any departmental work. Hence to reduce lead-time from design to manufacturing, different companies make use of various CAD/CAM/CAE software, which are available in market.

1.1 Computer Aided Design-

Computer aided design packages are powerful drawing tools. It follows user's instruction and produces the exact drawing, user wanted. Design packages are combination of design, geometric modeling and computer graphics. Computer aided design can be defined as computer systems to assist in the creation, modification, analysis or optimization of design.

These application programs include the modeling of 3-D component, stress-strain analysis of component, heat transfer calculation etc. Various CAD software are CATIA, Solid Works, Pro-e, Uni-Graphics, CAD Key, IDEAS, and Ansys, Solid Edge etc.

1.2 Customization

In today's world different companies are using different, general purpose CAD/CAM/CAE software. The CAD software available in the market are general purpose