Optimization of Bumper Design by using Crash Test

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***Abstract*—Occupant safety is a major problem in automobile industry, which is primarily characterized by vehicle deceleration pulses and deformation of the occupant compartment. Vehicle crashworthiness as measured in standardized crash tests is currently ranked at equal level to quality, styling, ride and handling, and fuel economy The crashworthiness of vehicle structures is enhancement by changing the structure design and material. . Crashworthiness evaluation is ascertained by a combination of tests and analytical methods.The behaviour of vehicle under collision can be predicted by using LS DYNA. The main focus of the project is on vehicle safety, which means the structural crashworthiness and reduction in occupant fatalities and harm.**

Keywords—crashworthiness; safety; crashtest; LS-DYNA.

I. INTRODUCTION

A crash test is a form of destructive testing usually performed in order to ensure safe design standards in crashworthiness and crash compatibility for various modes of transportation or related systems and component. The behaviour of three novel designs for circular crush-cans is studied. Half a tube (clamped end) is made of aluminium and the other half is made of steel. Half a tube (clamped end) is made of steel and the other half is made of aluminium. The stress concentration region is reinforced with steel and the rest of the tube is made of aluminium. The homogenized modeling technique and to investigate the behavior of a prototype aluminium honey comb satellite structure under various kinds of mechanical loadings describes the static and dynamic analyses of prototype satellite structure..Aluminium based honey comb material is frequently being used in the aerospace industry due to its high stiffness to weight ratio, good out of plane, in plane properties and low material and processing cost. Homogenized modeling approach for Honeycomb was discussed and later applied to a prototype satellite structure composed of Aluminium based honeycomb to characterize the behavior of the composite material under dynamic loading which was accomplished by performing several structural analyses to justify the design of the said prototype structure.The behavior exhibited by the honey comb based structure under static and dynamic loadings seems logical and the analyses results make sense and this certainly conforms to the fact that homogenized approach is quiet capable of predicting the behavior of the structure under dynamic loadings. deformation behaviour of sandwich structures with honeycomb core was carried out in the cases of quasi-static and dynamic loading in this study. According to these results the numerical models were validated and the numerical modeling by finite element method of sandwich structures behaviour under impact loading results energy absorption of by between 50 % and 95 % energy of all sandwich structure. The top face sheet absorbs by between 7 % and 35 % and bottom face sheet the least.

A crash load absorption structure for a motor vehicle. The structure includes a compressible load absorbing structure. It includes a front portion and a rear portion. The front portion and the rear portion are arranged to compress under a crash load along a generally longitudinal direction. The load transfer element may apply the crash load directly to the load absorbing structure at the location partway along the load absorbing structure. The load transfer element advantageously may promote a lower energy mode of compression or collapse of the load absorbing structure in a crash and may extend the duration of the acceleration pulse and/or increase the time that a motor vehicle takes to decelerate to zero velocity and/or provide a lower acceleration for the driver and/or other occupants during a crash.

The design of a crashworthy device or system is governed by its ability to limit the magnitude of the force by ensuring large elastic–plastic deformation . In cases involving passengers, in addition to the above, the purpose of a crashworthy system is to (i) dissipate the kinetic energy of the impact in a controllable manner, (ii) retain a survival space for the occupants, and (iii) minimise the forces and accelerations experienced by the occupants. Aluminium alloys have approximately 1/3 the weight of steel and 1/3 the stiffness, and usually a lower strength. Therefore, replacing a steel section with an aluminium one possessing a 50% thicker wall, should result in the same stiffness together with a weight reduction.

II. CRUSH CAN TECHNOLOGY

A new technique can be introduce to improve the crashworthiness and to enhance the safety standards of the car The structural cans were attached to the structural rails of the car and tucked behind the front bumper, the hollow metal structures collapse progressively, soaking up crash energy as they do. In a low-speed collision, they can help reduce damage to the car's front end and components such as the cooling system and horn. In many cases, the structural rails would suffer no damage, and a body shop may be able to just unbolt the bumper and replace the crush cans. If the crash energy does get into the cabin, it can cause occupant injury, especially if portions of the passenger compartment intrude and slam into the people inside. The safest car is one that crumples around an impact passenger cabin.

A. Function

Each of the two cans used are constructed of hollow pieces of metal that can be found between the bumper and the front end of the vehicle structure. Somewhat like squeezing aluminum can, the crush cans are also squeezed, but because high-strength metals are used the resistance force is much more effective.

B. Material

Aluminium is the metal used in many industries to manufacture a large variety of products and is very important to the world economy. Structural components made from aluminium and its alloys are vital to the aerospace industry and very important in other areas of transportation and building. It is widely used for foil and conductor cables, but alloying with other elements is necessary to provide the higher strengths needed for other applications.The properties of aluminium are

- Relatively low cost
- Best for energy absorption
- Greatest strength
- Less weight
- Thinnest cell walls

C. Aluminium Honey comb structure

Fig 1 : The aluminium honey comb structure ia shown below.

The advantage of the hexagonal structure of the honey comb are

- There is no lost space between hexagons. For example: squares can be placed on top of each other and on their sides, while if circles are stacked on their sides or on top of each other, there are parts between the circles that are not used.
- Strong structure, one of the strongest known shapes is the circle, and the hexagon is the closest to the circle without lost space.
- Large storage, like circles, they have more area covered then other shapes such as squares.

III. METHODOLOGY

Mass of the Car = 2ton
Velocity = 60 km/hr
Kinetic Energy = $\frac{1}{2}mv^2$
= 277777777.8 N-mm
Assumption 70% of energy to be absorbed, then
Kinetic Energy = 277777777.8*0.7
Absorbed kinetic energy = 194444444.4 N-mm
Stiffness =
For Cylinder Model,

Length = 200mm Diameter = 80mm Thickness = 20mm
Area of cylinder = πr^2

For Cube Model:

Length (a) = 150 mm
Area of cube = a^2

For Cuboid Model,

Length = 150mm Width = 100mm Heigth = 100mm
Area of cuboid = Length x Breadth x Height

Table 1 : Stiffness of different materials for cylinder

Material	Area of cylinder mm^2	Young's modulus N/m^2	Stiffness N/mm
Aluminium	5026.548246	70	1759291.886
Steel		200	5026548.246
Polystrene		3	75398.223
Carbon fiber reinforced plastic		150	3769911.184

The value of stiffness is calculated for various materials.te corresponding stiffnes and area of different material and different shapes were tabulated. The more stiffness the material have will resist the deformation. The amount of energy absorbed greatly upon the stiffness and area of cross section of load applied.

Table 2 : : Stiffness of different materials for cube

Material	Area of cube mm^2	Young's modulus N/m^2	Stiffness N/mm
Aluminium		70	10500000
Steel		200	30000000
Polystrene	22500	3	450000
Carbon fiber reinforced plastic		150	22500000

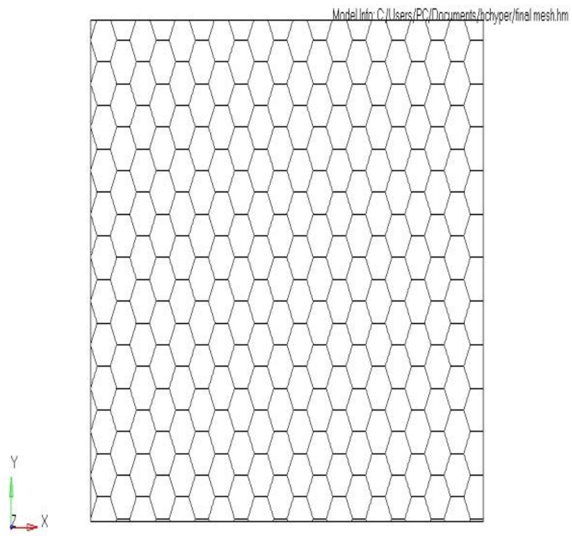
Table 3 : Stiffness of different materials for cuboid

Material	Area of cuboid mm^2	Young's modulus N/m^2	Stiffness N/mm
Aluminium		70	1050000000
Steel	2250000	200	3000000000
Polystrene		3	45000000
Carbon fiber reinforced plastic		150	2250000000

IV. MODELING AND MESHING

Altair Hyper Mesh is a high-performance finite element pre-processor that provides a highly interactive and visual environment to analyze product design performance. With the broadest set of direct interfaces to commercial CAD and CAE systems, Hyper Mesh provides a proven, consistent analysis platform for the entire enterprise.With a focus on engineering productivity, Hyper Mesh is the user-preferred environment for

- Solid Geometry Modeling
- Shell Meshing
- Model Morphing
- Detailed Model Setup
- Surface Geometry Modeling
- Solid Mesh Generation
- Automatic mid-surface generation
- Batch Meshing



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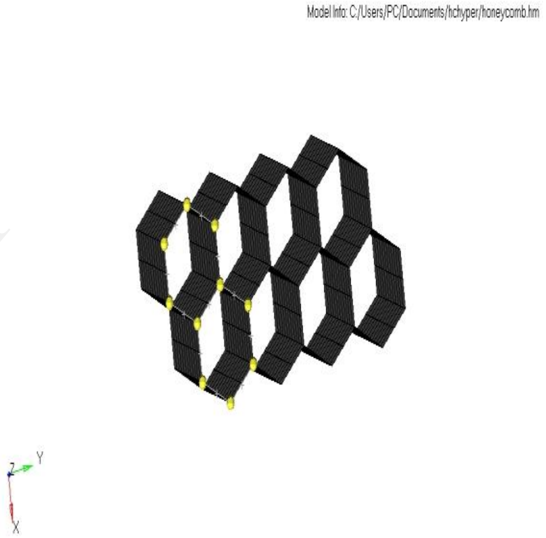
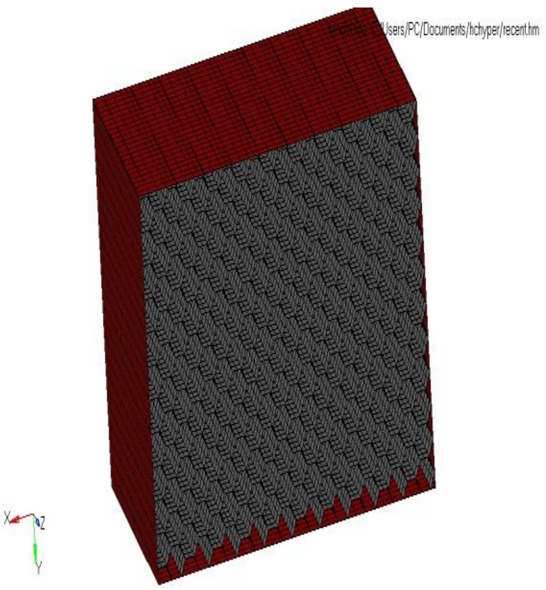
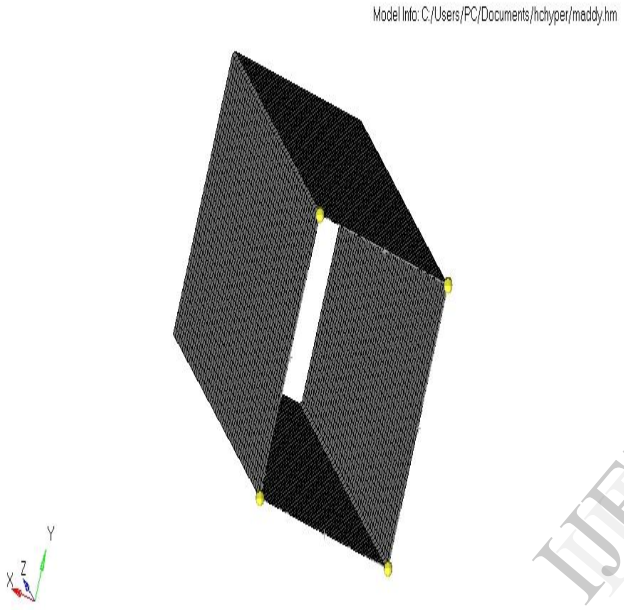


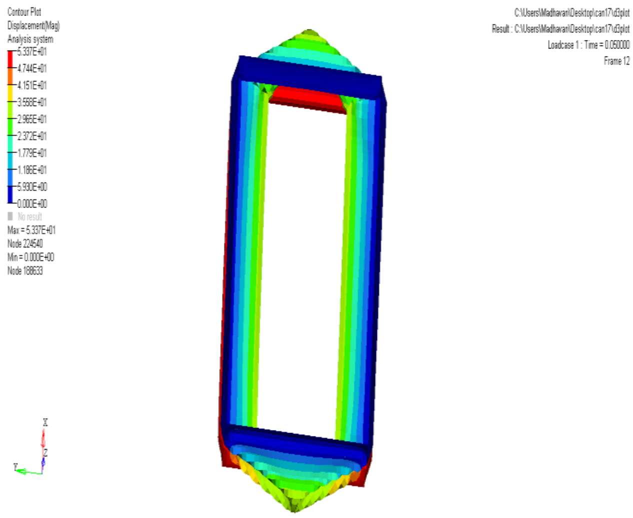


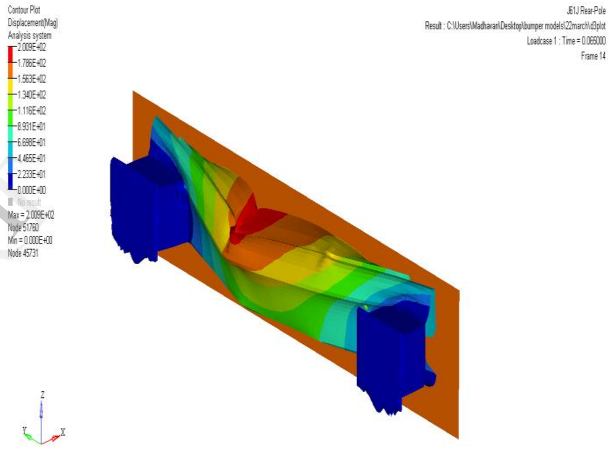
IV. AUTOMOBILE CRASHWORTHINESS

LS-DYNA is widely used by the automotive industry to analyze vehicle designs. LS-DYNA accurately predicts a car's behavior in a collision and the effects of the collision upon the car's occupants. With LS-DYNA, automotive companies and their suppliers can test car designs without having to tool or experimentally test a prototype, thus saving time and expense. AA6061-T4 and 5052-0 are chosen for crush can as materials since they have low tensile strength.true strain values are calculated for both materials. The crush can is made of aluminium and analyzed. The dimensions are length = 150mm, breadth = 100, height = 99.5mm.



The cuboid model foe the analysis is taken into account.The honey combstructure of the design is fixed in front of the and between the bump





V. CONCLUSION

The different shapes for the crush can are studied and cuboids seem to be suitable. Aluminium which is cheap and easily available is suggested as better material for the crush can. The existing bumper models are been revised and improved which shows more improvement in the absorption of impact energy during collision. The honeycomb structure crush can absorbs more energy than the plain crush can. The Aluminium alloys of AA6061 and AA5052 are taken into account and it is analyzed. From the analysis AA5052 absorbs more energy than AA6061. Finally the implementation of crush can will absorbs more energy secondary to the bumper which helps to improve the crashworthiness and increase the safety standards of the cars. The approach and designs presented can be employed for further optimization and development of other innovative design solutions. Optimization of the crush-can behavior is done within the limits of the front impact scenario with the purpose of improvement of the structural performance.

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