DESIGN AND ANALYSIS OF CHASSIS AND IMPACT ATTENUATOR

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ABSTRACT: Impact Attenuator is a device intended to reduce the damage to structures, vehicles, passengers etc., it is also known as crash cushion. In the development of the impact attenuator, models were built and parametric studies were set up to observe the influence of wall thickness, semi-apical angle, indentations and protrusions on crash performance. Optimizations were set up to evaluate optimum values of these parameters. In the end, a conical frustum shell-type impact attenuator which incorporates asymmetric indentations and protrusions was proposed. Generally, in the automotive industry, weight reduction, cost of engineering design and reduction in vehicle development cycle time are becoming increasingly focused on. In order to tackle this, Computer Aided Engineering (CAE) is popularly being used to lead design process. Similarly, in the design of the chassis, Finite Element Analysis (FEA) techniques have been adopted.

The effectiveness of the impact attenuator was measured by comparing the force transmitted through the chassis “with and without the impact attenuator" into the cockpit area. The impact attenuator reduces the amount of force transmitted into the cockpit area of the chassis to an appreciable level.

Key Words - impact attenuator, conical frustum shell-type impact attenuator, Computer Aided Engineering (CAE), Finite Element Analysis (FEA).

1. INTRODUCTION

Each year more than one million people are killed in road accidents .In India in 2016, nearly two hundred thousands were injured in road accidents. The majority of fatalities and serious injuries occurred due to frontal vehicle collisions. Considering this, safety is of paramount importance in modern vehicle design, crashworthiness is the first analysis to be completed in modern vehicle design.

The nonlinear finite element method is the state of the art tool in modern vehicle design for safety. This method enables the designer to investigate different designs easily and reliably. This is very important especially at the initial design stages, at which the design is uncertain and different alternatives are to be tested. Another advantage of the nonlinear finite element method is that, it reduces the total number of Prototype testing. This is also very important, since vehicle crash tests are expensive and time consuming. The Response Surface Method (RSM) is one of the approximation techniques that have been successfully used by many researchers to model the important crash responses.

Applying optimization at early design stages has been proven to be an efficient means for improving product design at even later design stages, which will ultimately reduce the total product cost. Weight reduction is a very important goal in modern vehicle design. Reducing weight will lower fuel consumption and consequently carbon emissions.

Impact attenuator is typically used as crash energy absorbing systems and is usually called crush elements. During a frontal collision, they help in absorbing part of the amount of impact energy and more importantly they reduce the impact forces transmitted to the occupants. This is very important since very large forces can cause irrecoverable damage. Thus, impact attenuator help in reducing the risk of injuries and in improving the crashworthiness performance of the whole vehicle.

2. MOTIVATION

This new impact attenuator development is an idea that is based on the curvature that is being present a normal egg.

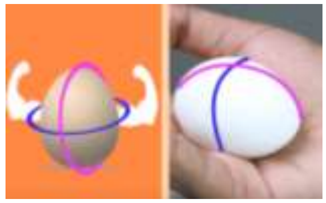


Fig.2.1: Motivation Product

Only because of the curvature that is present in the egg we cannot break it immediately by applying low force. As the angle of curvature increases more the strength an item gets. This technique of using curvature is being used potato chips making, that is why even it is thin it is not broken during transportation.

3. CHASSIS DEVELOPMENT

A full Computer Aided Engineering (CAE) approach is used to generate design concepts for the chassis structure. This is quite a different approach from how the chassis has been designed in the past. The design problem in view of weight reduction and increasing torsional stiffness is solved by means of topology optimization and also by applying gauge optimization at the later stage of the design phase to optimize the size of structural members of the chassis.

3.1 Design Optimisation

Optimisation was used to generate new design and optimal material distribution based on a package volume. This process allows one to start with a design that already has the advantage of optimal material distribution and is ready for design fine tuning.

3.2 Topology Optimization

Topology optimization was performed on the design space to create a new topology for the structure, removing any unnecessary material. The resulting structure should be lighter and satisfy all design constraints.

3.3 Chassis Modelling

This chassis modelling Concept is a tube and sheet component design, which helps in reducing the weight and also with an increased torsional stiffness.

At the end of the optimisation, the optimum thickness of the sheet component was calculated to be 1.478 (≈ 1.5mm) and torsional stiffness was 751.3Nm/ º. This concept weighs 24.89kg giving a specific torsional stiffness of 28.7Nm/ º kg.

4. IMPACT ATTENUATOR DEVELOPMENT

An Impact attenuator is designed to absorb energy at the start of a crash and guide impact forces into the rest of the car body structure. At low speed, the damage to the car should be minimized. Similarly, at high speed, the device should guide forces generated from the impact into the car body structure in a manner that the possibility for collapse is low and most essentially to prevent passengers and driver's death.

In this design concept thin-walled shell type impact attenuator has been selected. It has been proven by many researchers that this type of crash absorber dissipates energy under adverse effects of impact and thus offers excellent protection to the structure being considered. It is also cheap, efficient and reliable, they are popularly used as energy absorbing devices. Parametric study is carried out to understand how wall thickness and shape of the impact attenuator influence its crash performance.

The dimensions have been selected as: H = 200mm, D =200mm, d =100mm, T = 2.0mm. The material type for the impact attenuator was chosen to be "Material type 24 elasto-plastic material". The material selected was aluminium alloy AA6063T6 which mechanical properties are as follow - density 2700 kg/m 3, Poisson's ratio 0.33, elastic modulus 68.9Gpa, yield stress 225Mpa and tangential modulus 0.8099Gpa.

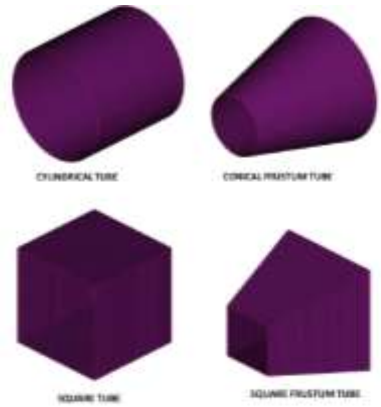


Fig.4.1: Impact Attenuator Models

For this analysis the impact attenuator with curvature and also some already used boxy designs impact attenuator is being analyzed for obtaining the best design. So, analysis is done in a Cylindrical, Conical Frustum, Square, Square Frustum Tube type Impact Attenuator.

From the analysis the following results were obtained;

Impact Attenuator	Mass (kg)	Kinetic Energy (J)	Max. Energy absorbed (J)	Max. Section force (KN)
Cylindrical tube	0.679	7366.27	7200.61	141.72
Conical frustum tube	0.524	7362.58	**7239.27**	112.33
Square tube	0.864	7370.72	7160.54	119.89
Square frustum tube	0.668	7366.04	7126.12	81.13

Table.4.1: Analysis Results

It is apparent that the conical frustum tube absorbed the highest amount of energy, and also less mass compared with the rest of the design. Therefore conical frustum type impact attenuator is selected for further analysis and testing.

5. Crashworthiness Of Chassis With And Without Impact Attenuator

Crash test analysis is done with chassis with impact attenuator and also chassis without impact attenuator. For this analysis few boundaries as well as load are being assumed and they are: Mass of the Driver M_d = 77kg, Mass of the Chassis M_c=25kg, Mass of the Engine M_e = 198kg and the velocity of the moving car is assumed as v=7m/sec.

Then the analysis is carried out and from the result it is very clear that the force transmitted into the cockpit area is very high in chassis without impact attenuator and less in the chassis with impact attenuator.

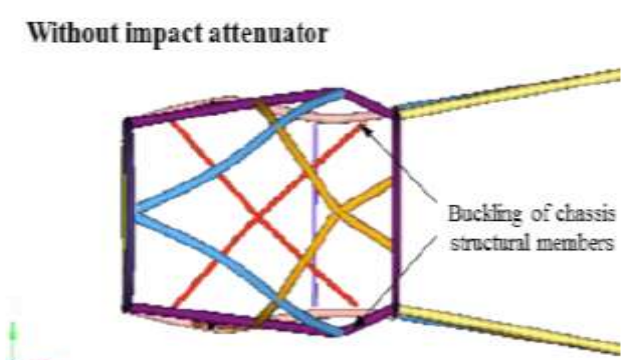


Fig.5.1: Chassis without Impact Attenuator

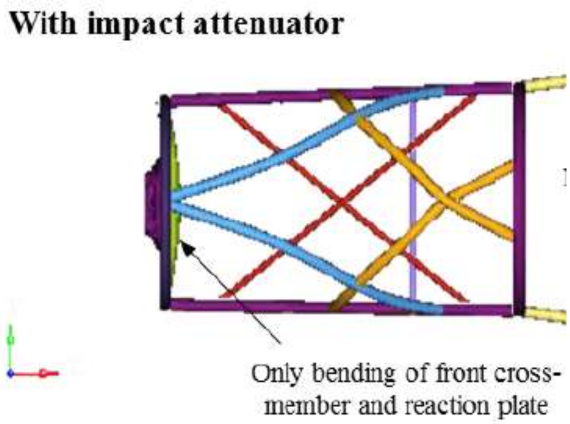
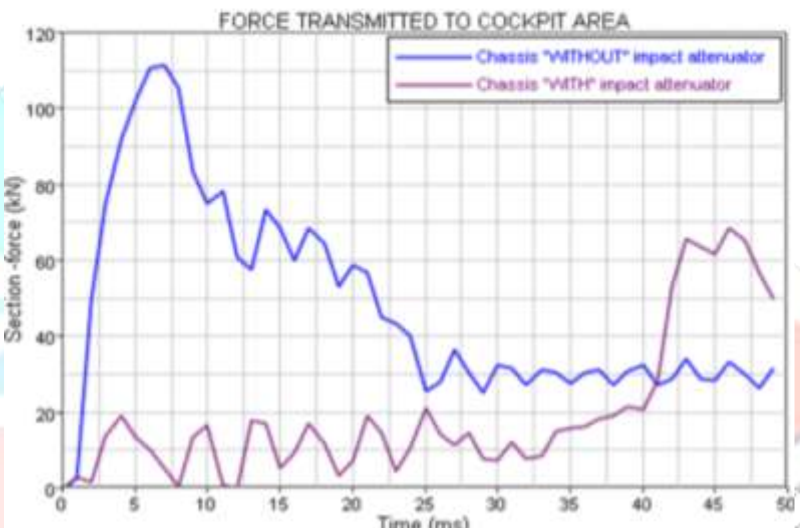


Fig.5.2: Chassis without Impact Attenuator



Graph.5.1: Section force vs. Time

6. Conclusion

When the impact attenuator was mounted onto the chassis, the impact force transmitted to the cockpit was considerably reduced. This clearly shows that the device would help preventing injury to the driver and also the passengers.

The effectiveness of the impact attenuator was measured by comparing the force transmitted through the chassis "with and without the impact attenuator" into the cockpit area. The impact attenuator helped to reduce the force to an appreciable low level, decreased by almost 50%. The device also helped in preventing buckling of the chassis structural members by limiting the force propagated through the structure.

7. References

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