

# Design, Optimization & Experimentation of an Impact Attenuator to Reduce Impact on Vehicle during Accident

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**Abstract**— Impact attenuation is promising technique used in automobile industry to absorb the impact for sake of driver's safety. It is important to analyze the impact attenuator for crash worthiness. Honeycomb structure is analyzed as impact attenuator for its impact energy absorption capacity with different material in order to ensure drivers and occupants safety in case of high speed crashes. This paper provides a review on Impact attenuator and impact attenuation techniques using different structures.

**Key words:** Crash Analysis, Impact Attenuation, Impact Attenuator, Honeycomb Structure

## I. INTRODUCTION

In many developing countries, where there is a significant increase in vehicle traffic combined with poor road infrastructure, inadequate training of drivers, and a lack of good police control, the traffic injuring rates are enormous. Road traffic crashes are known to be a leading cause of deaths and injuries in India in the past decade. The majority of road traffic fatalities occurs on roads in rural areas. In India about 58% more people die on roads in the rural areas than in urban areas, and generally more severe crashes occur on rural roads compared with urban areas. Considering the fact that about 70% of the population in India lives in rural areas, coupled with the fact that the majority of the rural residents are engaged in agricultural activities that supports the economy of the country, it is evident that these accidents and their consequences affect the food supply and the economy of the nation. Formula SAE motorsport is a platform for maximum race car driving performance resulting from high-tech developments in the area of lightweight materials and aerodynamic design. In order to ensure the driver's safety in case of high-speed crashes, special impact structures are designed to absorb the race car's kinetic energy and limit the decelerations acting on the human body. These energy absorbing structures are made of laminated composite sandwich materials - like the whole monocoque chassis - and have to meet defined crash test requirements specified by the Formula SAE Rules and Regulations. This study covers the crash behaviour of the front impact structure of the Formula SAE racing car.

## II. IMPACT ATTENUATOR

Impact Attenuator is device used to absorb impact by its self-destruction so that less amount of impact force is transferred to the body of vehicle. It is used to reduce damage done to structure, vehicle and motorists resulting from a motor vehicle collision. Impact attenuator absorb vehicles kinetic energy or redirect vehicle away from the hazard and form road work machinery and workers also decelerates impacting vehicle gradually to stop. The main objective of this research is to study different impact attenuation technique and

honeycomb structured impact attenuator for its crash worthiness with different possible materials. Fig-1 depicts the specification and experimental setup of impact attenuator testing.

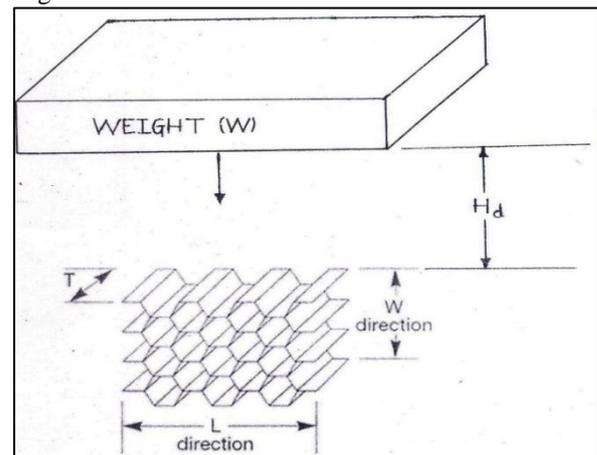


Fig. 1: Proposed Experimental Setup of Impact Attenuator Testing

## III. RELEVANCE

Now-a-days large numbers of accidents are observed and the many lives have been lost due to the crash between the vehicles. The ideal crash would be no crash at all. But, let's assume there is a crash, and that the best possible chances of survival are to be calculated. How can all of the safety systems come together to give you the smoothest crash possible?

Surviving a crash is all about kinetic energy. When the body of occupant is moving, it has a certain amount of kinetic energy. After the crash, when it comes to a complete stop, it will have zero kinetic energy. To minimize risk of injury, removing the kinetic energy as slowly and evenly as possible is done by some of the following safety systems in the car: -

As soon as car hits the barrier the seatbelt can then absorb some of your energy before the airbag deploys.

Milliseconds later as the driver moves forward towards the airbag, the force in the seatbelt holding him back would start to hurt him, so the force limiters make sure that the force in the seatbelts doesn't get too high.

Next, the airbag deploys and absorbs some more of the forward motion while protecting the driver from hitting anything hard. In a crash it is desirable that most of the crash energy is absorbed and dissipated in the deformation of components of each vehicle.

Crumple Zones are vacant spaces in the front portion of the car that act as cushions, where metal parts are supposed to deform and absorb all the kinetic energy of the vehicle.

The engine on most cars is mounted so that in a crash, it is forced backwards and downward so that it won't come into the cabin and injure the occupant. Thus keeping the driver's safety in mind.

Impact attenuation is the promising technique used in Automobile industry to absorb the impact for the sake of Driver's safety. The importance of this technique has been stressed in the coming years with the advancement of the technology to increase the safety factors of the automobile increasing its value. Various devices and materials are used in the form of impact absorbing substance. The device is supposed to absorb the impact by its self-destruction so that less amount of the impact force is transferred to body of the vehicle.

An impact attenuator is a structure used to "decelerate impacting vehicles gradually to a stop" By gradually decelerating the race car, the frame and driver are protected from significant deformation and injury. The bulk of impact energy is transferred into the deformation of the impact attenuator structure. Attenuators can be placed on vehicles or on road barriers to absorb large impacts to protect frames and people.

#### IV. LITERATURE REVIEW

Some work related to Impact Attenuator was carried out in recent years. Following are the list of researches who has worked in the area of vehicle Impact Attenuator for car safety. Jon Hart, Craig Kennedy, Todd Leclerc, Justin Pollard [1] FSAE Impact Attenuator. This paper commences with the review of the in-field fundamentals of Impact Attenuator. The Attenuator's purpose is to absorb impact energy, thus minimizing damage to the car frame and the driver. WPI's FSAE race car requires an impact attenuator that can protect the driver and frame when mounted on the front bulkhead of the vehicle. This paper gives information about the design, modelling, fabrication and testing of an impact attenuator.

Giovanni Belingard and Jovan Obradovic [2]. Vehicle safety is one of the major research areas in automotive engineering. The car industry is developing new passive and active safety systems and techniques to increase the safety of vehicle occupants. To reduce the development and testing cost of a new safety design, it is recommendable to use computational crash simulations for early evaluation of safety behaviour under vehicle impact test. A device which is intended to reduce the damage done to vehicle structures and possible injury to passenger resulting from a collision is impact attenuator. The main aspect of the research were oriented towards the dissipation of the kinetic energy during the front impact that should be as progressive as possible and towards the evaluation of the initial deceleration which has to be as little as possible.

Yavuzkllıc [3] In their work they have discussed the key requirements of crash protection is to absorb and dissipate energy. This energy dissipation is achieved through plastic work done in deforming the material in the crash structure. Therefore, by comparing the capacity of energy dissipation of different materials and considering their density, it is possible to assess which materials provide optimal energy dissipation per unit mass.

T. J. Hirsch and Don L. Ivey [4] the modular crash cushion, in its first generation form, is an arrangement of 55-gallon tight head drums positioned to protect motorists from inadvertently driving into rigid obstacles. This protective device is a crash worthy and economical vehicle impact attenuator. It has been subjected to five full crash test by the Highway Safety Research Centre of the Texas Transportation Institute. The purpose of modular crash cushion is to stop a moving vehicle over a distance sufficient to allow a relatively low deceleration rate.

M. Ashmead, O. Bedus, S. Bradley [5] safety is becoming an increasingly important subject for car manufacturer. To meet the present and increasing demand for enhance safety in cars, the ideal energy absorber should work as a multi-functional element. It should also function as a structural component, heat exchanger, an air filter, a liquid storage component, or an acoustic insulator. Sandwich structures can offer to designers many of the above benefits. Traditionally, these were made from foams (PU and PP), plastic ribs or honeycomb material, which are an interesting but an expansive alternative. In this paper press load is investigated in detail under the range of conditions and we will be examining its performance relative to other commonly available material, giving practical examples of how to apply it to critical locations within the car.

A. Gopichand, R. Mohanrao, N. V. S. Shankar, G. Rama Balaji, P. Sandeep Kumar [6] In this study a stainless steel chosen a face sheet and copper is a core material. Honeycombs are most often an array of hollow hexagonal cells with thin vertical walls Copper Honeycomb is low density permeable material with numerous applications. The defining characteristic of these Honeycombs is a very high porosity; typically 75-95% of the volume consists of void spaces. Static three-point bending tests were carried out in order to investigate load and deflection variations. The theoretical load and defections in copper honey comb sandwich panel values is adapted and compared with experimental and simulation results

Arpit Singhal, Vignesh S. Subramaniam [7] the impact attenuator is an energy absorbing device installed forward of the front bulkhead of the car with the function to absorb energy and to protect the driver from a sudden change of momentum experienced during an event of a collision. It achieves that by deforming plastically and absorbing a part of the total energy involved during a collision. Aim of this paper is to provide innovation towards the usual and conventional Attenuators for FSAE cars, and testing its effectiveness with drop weight test analysis providing average deceleration impact of vehicle to be less than 20g, which is required according to FSAE design rules.

Agvei-Agyemang [8] the goal of this work is to mitigate the degree of damage to passengers caused by automobile collisions. Crash phenomena involving road vehicles were investigated for the purpose of developing an impact attenuation design that can withstand speeds higher than the current specified range of up to 4 km/h (for a bumper). Different impact attenuation systems in the vehicle were studied with emphasis on the bumper modeling, analysis and design. A mathematical model for a bumper was developed.

Boria, Simonetta, Forasassi, Giuseppe [9] the aim of the present study is to investigate, experimentally and numerically, the energy absorbing capabilities of a thin-walled crash-box, made of aluminum sandwich material, for a racing car. The crash-tests were performed for a frontal impact at the velocity of 12 m/s; during the impact were measured the load-shortening diagram, the deceleration and the energy absorbed by the structure. A finite element model is then developed using the non-linear, explicit dynamic code LS-DYNA.

#### V. METHODOLOGY

The methodology which will be followed for the analysis of impact attenuator and to find crashworthiness of impact attenuator comprises the following:

- 1) Initially, theoretical study of Impact Attenuator will be done and also the study of absorption mechanism of crash energy and the deformation behaviour of honeycomb structured Impact Attenuator.
- 2) Selection of material from design data book will be done by considering the energy absorption capacity as main parameter and also considering weight and cost of material as secondary parameter.
- 3) Modelling of Impact Attenuator will be done by using CAD software like Catia or Unigraphics NX.
- 4) Meshing of Impact Attenuator will be carried out with the help of meshing software like HYPERMESH.
- 5) Analysis of Impact Attenuator with the help of CAE software like ANSYS-Explicit dynamics or LS-DYNA will be done to find out total deformation and energy absorbed during frontal impact for all selected possible materials.
- 6) Manufacturing the impact attenuator with any one material selected for study which absorbs maximum impact energy for given size and shape which is specified by FSAE Rules and Regulations.
- 7) Experimentation will be carried out by using drop test to find the results. All results will be compared to validate and finally the conclusion will be drawn.

#### VI. CONCLUSION

From this review it is observed that Analysis of impact attenuator by using Honeycomb structure as impact attenuator with different possible material provide the opportunity to find out the crash worthiness of impact attenuator for sake of driver and occupants safety by reducing damage done during vehicle collision.

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