Review on Design of Crumple Zone in Passenger cars for Improved Energy Absorption

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ABSTRACT

One of the important element in the automobile design is Crumple zone to enhance energy absorption. The purpose of a crumple zone is to increase the amount of time it takes the car to come to a complete stop and absorb impact energy when involved in a frontal collision. This is known as the vehicle's deceleration time. By increasing the time it takes for your car to come to a stop after you hit the object, the force is spread over a longer period of time, by a longer period, we mean milliseconds. Crumple zones work by managing crash energy, absorbing it within the forward section of the vehicle, rather than being directly transmitted to the occupants, while also preventing intrusion into or deformation of the passenger cabin. This achieved by controlled weakening of outer parts of the car while strengthening the inner part of the body of the car, the passenger cabin, by using more reinforcing beams and higher strength steels.

OBJECTIVE

The objective of the project presented here, was to design a better structure that substitutes the conventional energy absorbing longitudinal members in a frontal vehicle structure and yields optimized deceleration pulses for different crash velocities and overlap percentages at the same time comparing with physical test pulse. To this aim the structure must have a stiffness that can be varied in accordance to the specific crash situations.

The novel design presented in this thesis can cope with the following crashworthiness problems:

Comparing Acceleration pulse of Full vehicle with Base CAE Model.

With a not much longer deformation length, much more energy must be absorbed at high crash velocities (resulting in less fatal injuries) and a lower injury level must be obtained at lower crash velocities.

A deceleration pulse must be obtained which is optimal for the concerning collision speed.

Key words: CAE, Crumple Zone, Energy Absorption, Kinetic Energy

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INTRODUCTION

Nowadays passenger vehicle safety awareness is a key factor in choosing a car to be purchased. Therefore OEMs are aggressively designing vehicles with crash protection and safety features beyond the minimum standards set by national and federal requirements. Most of the improvements in crash safety performance have been obtained so far by increasing the vehicle body stiffness as well as introducing a larger number of air bags per vehicle. Starting from the current set of solutions, new Energy Absorption (EA) concepts to improve safety rating and/or optimize cost-weight are discussed. In particular the concept of Load Control alongside EA efficiency in case of passenger vehicle frontal impact will be described for improved energy management.

METHODOLOGY

Increased protection for the entire collision spectrum can be obtained by structures consisting of longitudinal members with an advanced geometric form, giving higher bending resistance without increasing the axial stiffness, in conjunction with a rigid connection between the front ends of these members. From several longitudinal square cross-sections, the influence of the width and thickness dimensions on the crash behavior is evaluated. The purpose of this study is to conceive an advanced geometric design for a longitudinal member optimized for a wide collision spectrum. The influence of various crash situations on the amount of energy absorbed by such longitudinal members will be discussed and representative crash tests are proposed. However, to reach a similar amount of energy absorption in case of an offset collision compared with a full overlap situation, additional measures are necessary. For this, the other longitudinal, which is not directly loaded, has to crumple axially as well.

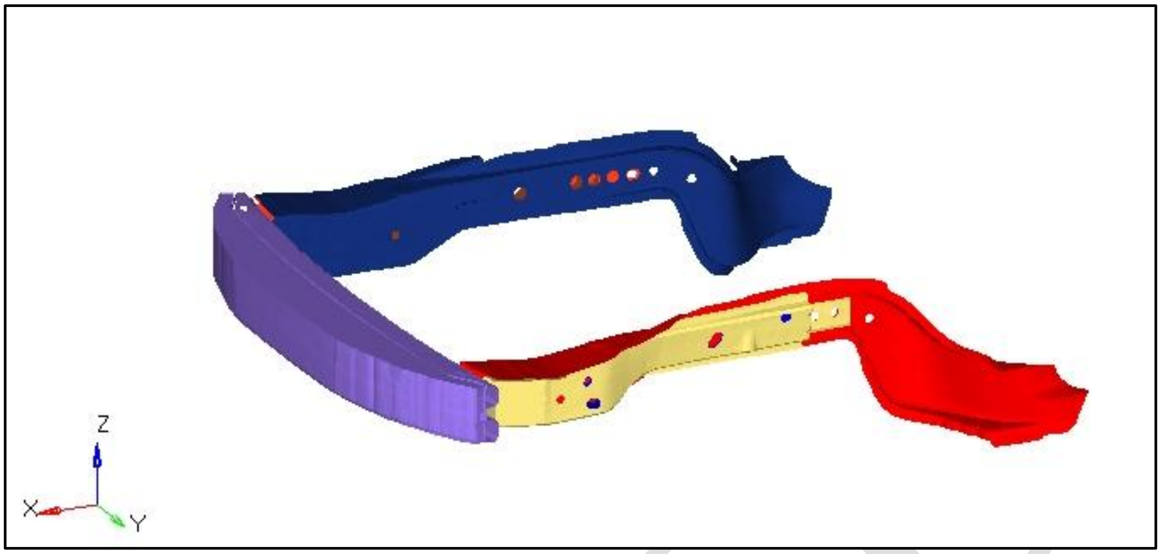

Fig.: Longitudinal members for Taurus Model

In these simulations, deceleration levels in the same order of magnitude are found, physical tests pulses were compared to CAE models and also the improved design of longitudinal members. Since it has been demonstrated that it is possible to design a vehicle structure which generates a crash pulse that is almost independent of the crash direction and overlap percentage, it is useful to do an independent search for optimal pulses at several crash velocities, because the found structure-based pulses are not obviously the optimal pulses for minimal injury to the occupants. From a described research an optimal pulse has been found after several considered pulse variations at a crash speed of 56 km/h. This pulse, used as example, deviates much from a traditional pulse, which shows normally an increasing stiffness of the structure near the end of the crash, but gives as it seems much lower injuries. During the first part of the deformation length the deceleration level can be high, then a low deceleration interval is desired, and at the end the deceleration can be high again. Also for other crash velocities, pulses are mentioned with adapted pulse characteristics for optimal results. Finally, new ideas are given how to further customize the energy absorption for different crash velocities to reach the optimal pulse. Therefore, an better structure must be built which realizes such optimal pulses as closely as possible.

CONCLUSION

Numerical simulation studies (CAE) have been performed analyzing the effects such as weak zones on longitudinal members such as like removing material and creating engineering features like beads for improving crash performance. These show that it is impossible to design a cross-sectional profile that provides an efficient and stable folding process with an acceptable axial stiffness and at both requirements are met simultaneously, since in actual car to car crashes about 60 percent of the crash energy cannot be absorbed by the frontal structure if that car was designed to only meet the compulsory full overlap test.

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