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Evaluation of Rectangular Front Load Beam for Energy Absorption

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Abstract: ***Frontal impact is still a major concern for automotive OEMs. The energy absorption of the front rail plays an important role in frontal impact. The S-rails are used in the front load beam and mostly front portion of the load beams is a rectangular section. In this paper rectangular column (load beam)with different parameters i.e. different rib (inside) thickness and materials, are evaluated using Finite Element Analysis. The front load beam comes under direct load path in Full frontal and ODB (Offset deformable barrier) impact. The acceleration pulse at the passenger cabin is affected by the design of rails. Good design leads to a reduction of occupant injury. The intrusion of the opposite vehicle is more in case of ODB and the acceleration pulse is in case of full frontal impacts. The front load beam (rail) works as a source of energy absorber between the bumper and the engine in both the cases.It prevents engine to hit the cabin to reduce the occupant injury. In this paper is impact speed of 50 km/h under dynamic conditions used to evaluate the rectangular column (load beam), a new design is proposed, which will provide a direction to the designers.***

Keywords: FE Analysis, Energy Absorption, Dynamic crushing, Thin walled structure, LS-Dyna

1. Introduction

Frontal vehicle collisions are the major type of car crash in the world, resulting thousands of deaths every year. Consumers have become highly aware of the importance of vehicle safety which has made it a primary selling feature now-a-days. Moreover, the competitive nature in the automobile sector persuades manufacturers to develop safer vehicles. Safety is paramount importance in modern vehicle design. Crashworthiness is themost important safety analysis to be completed. Vehicle crashworthiness, defined as the degree of occupant safety, when vehicle is involved in the collisions. Continuous work is beingdone by thedesigners tomake the front end of the vehicle to absorbmoreenergy to reduce the amount of occupant's head accelerations and to reduce lower and upper dash intrusion. Front load beam of the passenger vehicle is the major energy absorbing component of the vehicle. The acceleration pulse near Sill region is affected by design and behavior of front rail and its energy absorption from 20 to 40 milliseconds. The variation in section, thickness and material of rail affects the load path in case of frontal impact. The study is based on the FE analysis and helped to investigate the effect of change of rib thickness of a rectangular load beam.

2. Literature Survey

Ample of data and journals of several researcherswere analyzed. They have been worked on the rails to evaluate the energy absorption of the front rails.

Erdin et al evaluated a thin walled circular aluminium structure with graded structure. He observed the functionally grade thickness and uniform thickness tubes show the progressive crushing behavior. Kadam et al evaluated force –displacement of rail with different bead's size.

Sudjito et al, worked on segment based crash box. Their study evaluated the deformation mode and energy absorbing capability on two segments crash box design with a length of 100 mm due to frontal load.

Paulius G. Antanas Z., concluded that the value of the absorbed deformation energy in the experimental testing of the corroded longeron satisfies the results of FE model analyses. They used Steel DP 500/800 and HSLA 350/450 material and evaluated internal energies.

Paper of Chien H. et al, is focused on energy absorption efficiency improvement of the vehicle's front rails during impact and to provide better space for the occupants.Author has evaluated the effect of adding holes, beads on rails and also evaluated the effect of two rail systems.

3. Methodology

The amount of energy absorption at the front side of the vehicle is based on the Finite Element Analysis. At first the solid model of the a 300 mm long, 60*50*1.8 rectangular long column is created (Fig:1).This section is used as a base. The corner fillet of 5 mm is used in all the models.

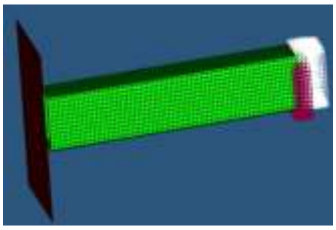
Figure 1: Solid model

Four more sections, with ribs are also created for the study. The section details are as follows:

A 60*50*1.8 mm rectangle with a single rib at the mid as shown in Fig.

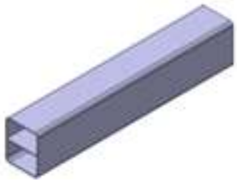

Figure 2: Section - SingleMid Rib

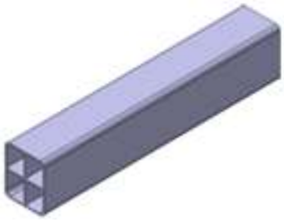

Figure 3: Section - Cross Mid Rib

The calculation of force and energy is given below.

$$P_E = 20.2 * Re^{0.382} * t^{0.860} \quad (1)$$

$$E = 0.158 * R_m^{0.506} * t^{1.498} \quad (2)$$

where P_E= peakload(KN)
E=absorbedenergy(KJ)
t =thickness(mm)
R_m =tensilestrength(MPa)

In this paper, study of rectangular column without inside ribs, inside single middle rib, cross ribs, cross ribs with varying thickness and different rib fillets are investigated and Force-Displacement are determined with 4 different materials i.e. Grade Steel, HSLA, DP & HSLA (Cold Rolled).

4. Result & Discussion

The simulations are performed by using LS-Dyna explicit tool. All simulations areformed on the dynamic impact conditions with 50kmph initial velocity.

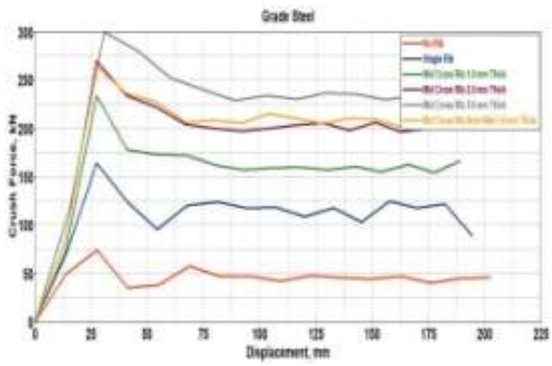

Figure 4: Result Comparison-with & without Rib – Grade Steel Material

It is obvious from the Figure 4, With Grade steel material, Peak crush force on section with single internal rib is 117% more as compared with section without rib. By adding the cross rib with the same thickness, the peak force value is 273% more than the value for the section without rib. Using cross rib thickness of 2.5 mm the peak force is 253% more as related to the section without rib. Using cross rib thickness of 3.0 mm the peak force value is 3 times of the force with section without rib. The force behaviour with 2.5 mm thick cross rib and with 5 mm fillet radius is similar.

5. Conclusion & Future Scope

Presented paper is useful for the automotive engineers to optimize the weight by using most suitable combinations and for proliferation of strength to weight ratio. There is substantial amount of energy absorption if only using 3.0 mm rib thickness instead of increase the full front rail thickness. Several research and industrial work is going on for weight reduction. Energy absorption of HSLA is medium.

In future more efforts will be made for designing front rail to reduce weight using more materials and thickness options.

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