PERVENTIVE DESIGN AND SAFETY ANALYSIS ON A CAR WITH ROLLOVER EFFECT USING LS DYNA

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Abstract
Rollover accidents of a car are the most occurring accidents that we see in our daily lives. The passengers experience major injuries like neck, head and spine injuries. So, to reduce the injuries of a passenger from major fatalities it is important to provide safety in the car. Though safety is provided by seat belts and airbags during accidents, the passenger must have sufficient space for survival in the car during accidents. The roof of the car must have high strength to resist the crush force to avail the passenger some space for survival. Therefore, in this project, we have carried out roof crush test using Federal Motor Vehicle Safety Standards (FMVSS216) standards in LS dyna software. We have used Hypermesh software to mesh the model and to apply boundary conditions to it. And the rigid plate is used to crush the car roof as specified by FMVSS216 standards. The rigid plate is oriented on the car roof as specified by Insurance institute of highway safety (IIHS). And an alternate material is used to the car roof structure to the baseline model to check the crashworthiness of new material. The outcome of test results of the new material's strength to weight ratio (SWR) was compared to baseline model and the new material is proposed for the roof (B-pillar) which is found to be more crashworthy.
Keywords: FMVSS216, highway safety, crashworthiness, LS dyna software, strength to weight ratio

Introduction

The purpose of this standard is to reduce deaths and injuries due to the crushing of the roof into the passenger compartment in rollover accidents. The resistance of the roof to intrusion is determined by astatic test, in which force of 1½ times the empty weight of the vehicle or 5,000 pounds, whichever is less, is gradually applied to the roof in the vicinity of the "A" pillar. The force is applied by a flat test device at a 25-degree roll angle (sideways) and a 5-degree pitch angle (forward) to simulate the direction of forces that can be encountered in a rollover. During the test, the roof may show no more than 5 inches of intrusion, as measured by the movement of the test device. Around a quarter of Australian light vehicle occupant fatalities, occur in crashes involving rollover crashes. These crashes tend to be more severe than most other types of crashes One factor associated with the risk of injury in a rollover crash is roof strength. Although there is no Australian Design Rule for roof strength, it is likely that all cars marketed in Australia would meet the requirements of US Federal Motor Vehicle Safety Standard 216 (FMVSS 216). FMVSS 216 was introduced in 1973 and required the front corner of the roof to withstand a quasi-static force equal to at least 1.5 times the weight of the vehicle, up to 127mm of deflection. This is known as a strength-to-weight ratio (SWR) of 1.5. An enhanced roof crush test is being introduced by National Highway Traffic Safety Administration (NHTSA) in the USA. This is the current FMVSS 216 test, followed by a similar load applied to the roof on the previously untested roof pillar on the other side of the vehicle. The minimums required in FMVSS 216 will increase from 1.5 to 3.0for light vehicles (gross mass under 2,700kg). Phase- in begins in September 2012, and all vehicles must comply by September 2016.

Some road safety advocates in the USA have proposed that a dynamic rollover test be introduced such as the Jordan Rollover System (JRS). This test involves spinning the car about an approximately longitudinal axis and dropping it so that a corner of the roof contacts the ground (simulated by a moving platform). There has been considerable debate in the USA and elsewhere about the usefulness of the JRS for determining occupant protection. This appears to be partly because JRS test results have been used\ in litigation cases. It is likely to be several years before a dynamic test is available that is suitable for either regulatory or consumer rating purposes. In 2008 the US-based Insurance Institute for Highway Safety provided detailed comment on NHTSA's proposed changes to FMVSS 216. IIHS made

the following comments about dynamic rollover tests.

Objectives of the study

- In order to avoid the deformation of roof and its supporting members up to the residual space, different approaches were used i.e. Geometrical and Material approaches. In geometrical approach the geometry of roof and its supporting members i.e. A pillar, B pillar etc. has to change.
- But it is not applicable to all cases hence material approach was used. In this approach shock absorbing materials were inserted in roof body and pillars to improve their strength.
- The main objective of this paper is to study both these approaches, different materials and testing methods and determine the best method for improving roof and pillars of a vehicle.

Review of Literature

Dalkilic AS and Wongwises S[1] The study shows that HCR134a hydrocarbon refrigerant could be an alternative refrigerant for replacement the existing R134a refrigerant. Harby K[2] Results of the study showed that in spite of highly flammable characteristics, hydrocarbons can offer proper alternatives to the halogenated refrigerants from the standpoint of environment impact, energy efficiency, COP, refrigerant mass, and compressor temperatures. Pearson SF [3] concluded that R-134a have better performance than the R-22 also R-134a have zero ozone depletion potential and less global warming potential compare to R-22. The Metal particle of Al_2O_3 present in R-134a makes the Refrigerant efficient because of heated immediately. Another side R-744 which is made by recycling of CO_2 from atmosphere does not have any CFCs and also not hazardous to atmosphere also is very efficient refrigerant. R-744 has zero ODP, lowest GWP, non-toxic, and higher refrigerant performance than other refrigerants .Saleh B [4]The paper conclude that the BACKONE equations of state give generally a good accuracy for all thermodynamic data of refrigerants with the advantage of needing only few experimental data for the determination of its substance specific parameter. Yoon SH et al. [5] the paper that the heat transfer coefficients and pressure drop during the evaporation process of carbon dioxide in a horizontal tube have been investigated and At a low mass quality region during evaporation, heat transfer coefficient increases as mass quality increases because convective boiling becomes more dominant. But when mass quality is greater than a certain value, heat transfer coefficient tends to decrease. It is because surface tension. Neksa P [6] The paper concluded that CO_2 is one of the natural substances and it is an environmentally benign, safe and economical refrigerant used for heating and cooling systems. Existing CO_2 HPWHs both in industrial and residential sectors have been reviewed in this study, i.e. low-temperature and high-temperature HPWHs (which are classified by the heat delivery temperature below and above 80 °C). The majority of the existing systems are still not able to deliver the water temperature above 100 °C due to the temperature gliding matching between water and sCO_2, the limitations in compressors, and the constraints in heat exchangers. Hesse U [7] Taking in consideration the current climate scenario many researchers has done to develop a refrigeration system that is both energy efficient and has less impact on environment. This environmental impact is directly and indirectly related to the use of HCFC and HFC refrigerants in refrigeration systems. The amount of depletion of Ozone layer is link to the use of HCF seeds and HFC refrigerant whose consequence is measured why the ODP index that is ozone depletion potential. And also shows the potential alternatives of the chlorofluorocarbons. Suneel K Kalla [8] The Paper shows that the performance of four refrigerants as possible alternatives to R-22 was studied with the help of cycled software. The values of COP were nearer to those of R-22, e.g. at 25, 45 and 55 °C condensing temperature, COP of R432a is lower than that of R22 by about 5.5%, 4% and 4.38% respectively. By resorting to hydrocarbon refrigerant as a substitute to R-22 we can reduce global warming and avoid ozone layer damage due to use of other refrigerants. However, the drawback of hydrocarbon refrigerants is their flammability due to which safety measures during their use is essential.

Research Methodology

Due to the high effectiveness of ESC in preventing an increasing number of rollover crashes, and seat belts at

preventing ejection, the remaining target population relevant to roof crush occupant protection is a relatively small subset of the occupants 14 injured in rollovers. For fatalities, the estimated total for the target population is about seven percent (about 667) of all non-convertible light vehicle rollover fatalities. Although the target population and potential for lives saved are substantially smaller than can be attained by the first two strategies of our comprehensive rollover plan, it is nevertheless a very important aspect of the plan. Looking at the target population relevant to roof crush occupant protection more specifically. The target population for all light vehicles is stratified by injury severity.

The injury mechanism due to roof crush for belted occupants is that the roof crushes during the roll event, intrudes into the occupant compartment, and causes head, face, or neck injury. The table demonstrates how the final target population is derived from the broad category of rollovers by eliminating cases in which roof strength improvements would not be effective in reducing serious and fatal injuries. For example, a stronger roof would not be expected to provide benefits in cases where the roof was not involved; where the occupant was totally ejected from the vehicle or where the most serious injury was not to the head, neck, or face due to the intruding roof.

RESULTS AND DISCUSSIONS

We have to create a curve between Displacement vs time by using * Define curve. We have to assign this in *Boundary prescribed motion so that the rigid plate will press the body as shown in figure 1.

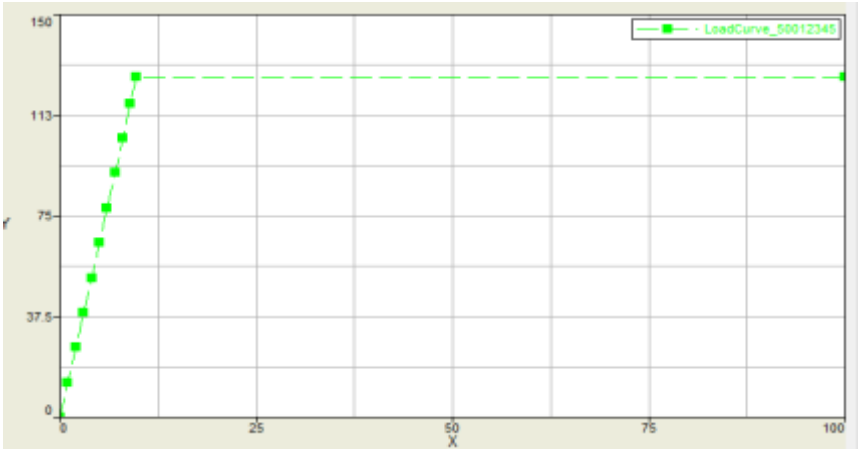

Fig 1 Displacements Vs Time

The main purpose of contacts is to detect the bodies during simulation. If we are not assi gning any contact then the body will penetrate . We have assigned * Automatic surface to surface contact for the rigid plate and the roof and single surface contact for the entire vehicle.In surface to surface contact we have to specify master and slave. Every time stiffer body should be master. So we have given master as rigid plate as shown in figures 2 &3.

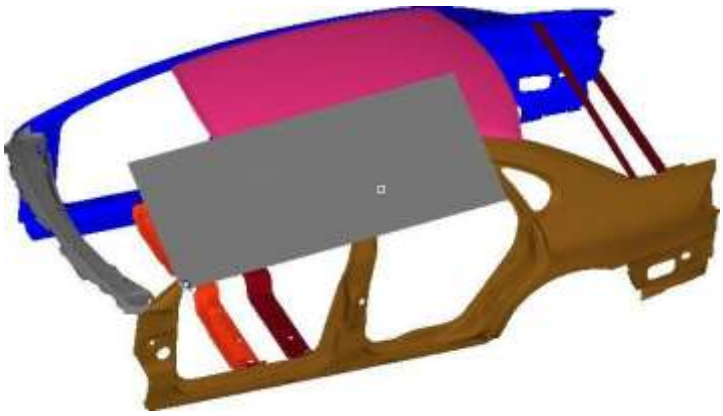

Fig.2 Model Before Giving Contact

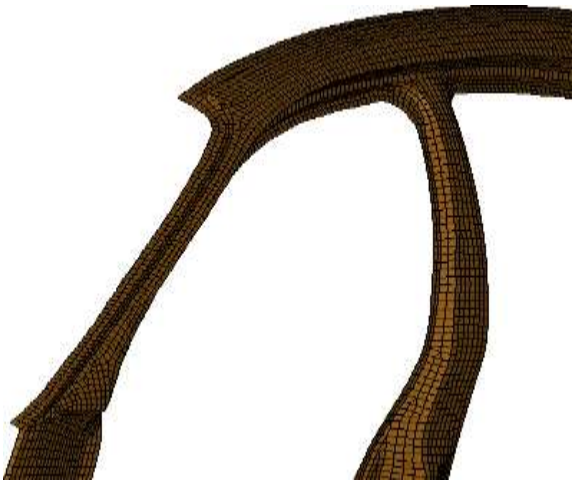

Fig 3 Before Analysis A-Pillar and B-Pillar

Fig 4 is the pillars before solving. This is the initial position of the pillars and after applying load there are deformations on the pillars which has been shown in Fig. 5

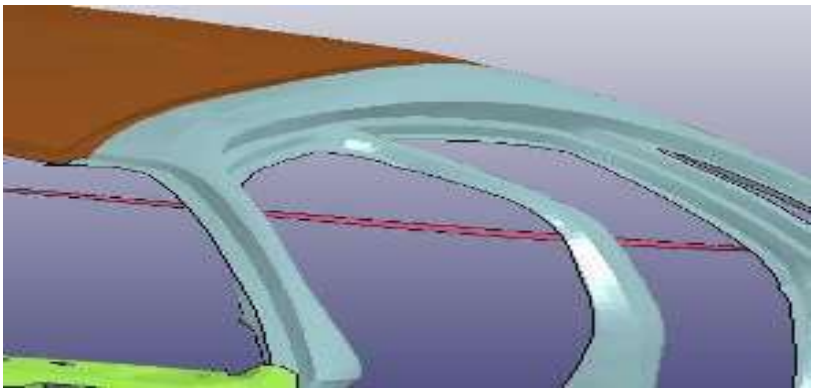

Fig.4 Displacements of A-Pillar, B-Pillar and Roof

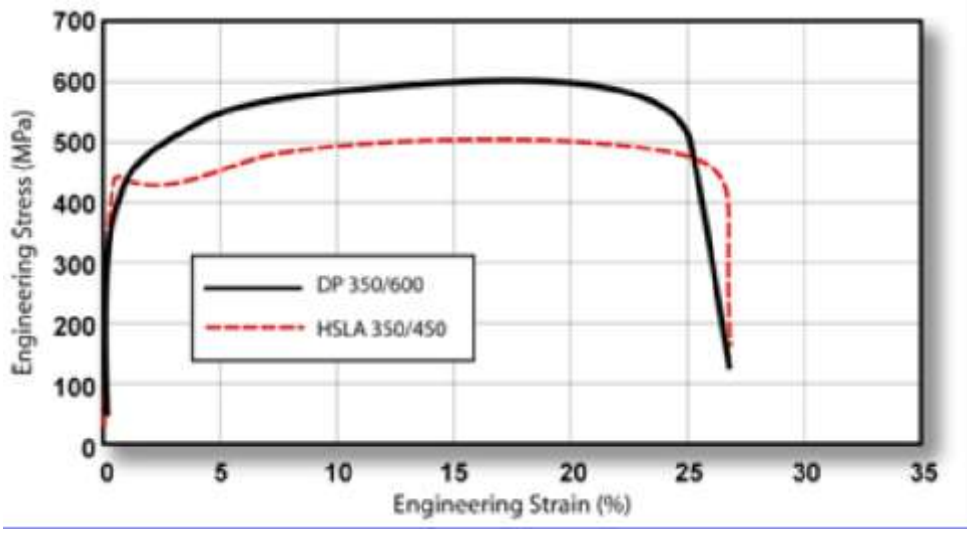

Fig.5 Stress-Strain Curve

The DP steel exhibits higher initial work hardening rate, higher ultimate tensile strength, and higher TS/YS ratio than a similar yield strength HSLA steel (High-strength low-alloy). Additional engineering and true stress-strain

curves for DP steel grades are located in Fig.6

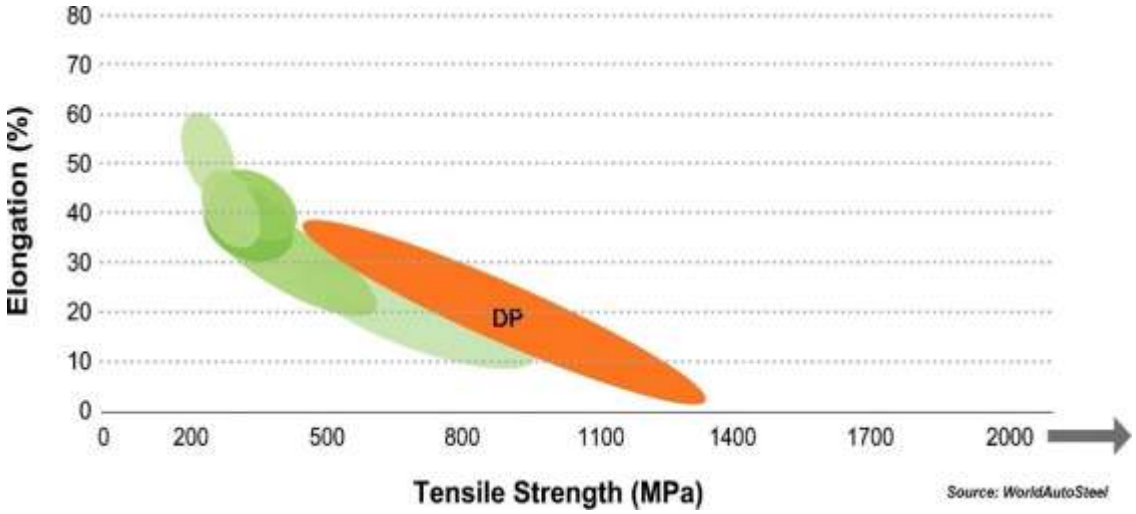

Fig. 6 Elongation and tensile strength of normal and dual phase steel

As per FMVSS standard, the reaction forces higher than 42.6 KN said to be a good car body as shown in 7.

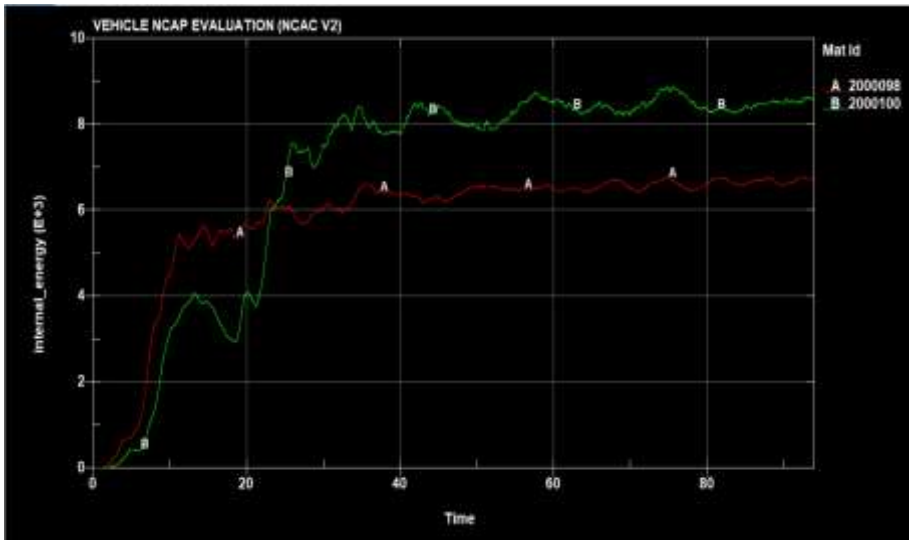

Fig.7 Internal energy absorption of steel and dual phase steel

CONCLUSION:

Vehicle rollover can cause serious risks to life. Roof crushes may damage occupant's head and neck and it is one of the serious road accidents. Only way to avoid or minimise these kinds of accidents is to strengthen the roof and supporting members of a vehicle. These techniques have their own characteristics of testing. Among these, FMVSS 216 standards are highly advanced and popular and being accepted in many universities and R&D centres across the globe.

The use of CAE methods is easy, cheap, flexible and highly accurate than actual testing. A FE model is created and tested virtually with the help of computer simulations. Lots of researches were carried on the improvement of roof and its supporting pillars and their performance testing methods.

The actual environment was created in labs similar to real road accidents to study exact loading conditions. Toyota Yaris, Ford Explorer and Honda Accord were tested by both the methods and the similarities between their results were discussed. These result showed that the amount of force required to deform the roof in the residual space of passenger cabin and the requirement of strength to prevent that. The strength of the roof can be increased by two approaches i.e. geometrical and material, were studied. Material approach is better than the geometrical because of space limitation in passenger cabin.

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