

# Study of Simulation and Validation of Automotive Seat Using the Regulation of FMVSS 207/210

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**ABSTRACT:**The purposes of this paper is to understand the importance of Federal Motor Vehicle Safety Standards 207/210 in occupant safety and second to enhance strength of driver seat failure components and to reduce the weight of the seat in an effort to create safety guidelines for the vehicles driver seat the Federal Motor Safety Standards 207/210 are applies. These regulations are to ensure their proper location for effective occupant restraint and it also in order to minimize the possibility of anchorage failure due to the forces resulting from vehicles crash. For the purpose, Driver seat model is taken from the National Crash Analysis Centre (NCAC) is modeled and analyzed using Hypermesh and LS-Dyna software's respectively as per standards recommendations. From the baseline results it is observed that the energy absorbed by the different components of seat is less where as the weight of the seat is more. An effort is made to overcome the seat weight without compromising the seat strength, by employing high strength steel and Aluminum. The results show that the aluminum is a good option to replace the general steel for the key components of the driver's car seat design and construction to ensure occupant safety.

**KEYWORDS:**FMVSS, LS-Dyna, Crash, lap block, Shoulder block

## I. INTRODUCTION

One of the main performance requirements of any automobile is to ensure occupant safety. The role of the automotive primary structure in providing safety to the occupants is paramount. Automotive structures are designed to maintain the integrity of the passenger compartment under all forms of collision. The ability of the structure to maintain its integrity in the event of a collision is known as crash-worthiness. The safety study of the automobile includes the study of vehicle structure and the study of the occupant behaviour in an event of crash of injury levels. Today virtual simulation is well established. Significant amount of safety or crash worthiness related study are performed at the early stages of product design using these software to come up with designs that are deemed safe under different collision conditions. Mulla Salim, et al [1], describes the importance of Federal Motor Vehicle Safety Standards 207/210 in occupant safety and enhancing the strength of driver seat failure components.

Case study in [1] shows a driver seat model taken from the National Crash Analysis Centre (NCAC). A finite element model of the same is created using Hypermesh and the crash simulation per FMVSS 207/210 is then performed using LSDYNA3D. From the baseline results it is observed that there is failure in seat tracks as failure strain produced 46% is higher than allowable strain 16.5% for the material. The authors in [1] suggest providing a J-bracket for the track as a feasible solution to prevent this failure. With this modified design, the resulting failure strain produced is 11% and is less than allowable strain 16.5% and hence enhances occupant safety.

VikasPatwardan, et al [2], discusses Federal Motor Vehicle Safety Standard 207 and 210 as applied to automotive seats, their attachment assemblies, and seat belt anchorage assemblies. These regulations ensure their proper location for effective occupant restraint, and it also minimizes the possibility of anchorage failure due to the forces resulting from a vehicle crash. These requirements are the most critical in seat development process and are generally considered the benchmark for an automotive seat's safety performance. This paper will discuss a simple but accurate method to

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simulate and validate the FMVSS 207/210 test. The methodology describes the use of lighter body blocks to reduce the dynamic effect, simpler seat belt formulations, and the right use of element formulations and contact interfaces. Peter Williamson et al [3], investigated a problem for which, during testing and simulation, notable interaction was seen between the seatbelt and the upper back rest of seat structure. In order to analyze that interaction a 2-D model of the shoulder belt complete with shell elements and a simple D-Ring model was constructed. That approach along with an alternative configuration has been touched upon. The paper also suggested some of the options that LS-DYNA uses to keep the simulation of the seat structure, including loading devices, stabilizing for which extreme loading and large deformation will be prevalent. The elements and models used i.e. dummy, seat and restraint system has been outlined and description of the pre- and post- processors used for simulation using LSDYNA3D has been highlighted.

## II. NUMERICAL SIMULATION MODEL AND METHOD

Toyota Yaris sedan passenger vehicle driver seat model is taken from the National Crash Analysis Centre (NCAC). Suitable changes are made in the model to acquire the standards requirement. The figure below represents the CATIA model of the seat considered for analysis purpose. The skeleton of the seat is constructed with all the brackets, frames, rails, tubes along with seat pan and B-pillar. Both the seat and B-pillar are connected to the floor of the vehicle. The figure 2.4 above represents the body block for lap belt anchorage for FMVSS standard, which is modelled according to the dimension specified by the FMVSS standard. The figure 4.6 above represents the body block for shoulder belt anchorage for FMVSS standard, which is modelled according to the dimension specified by the FMVSS.

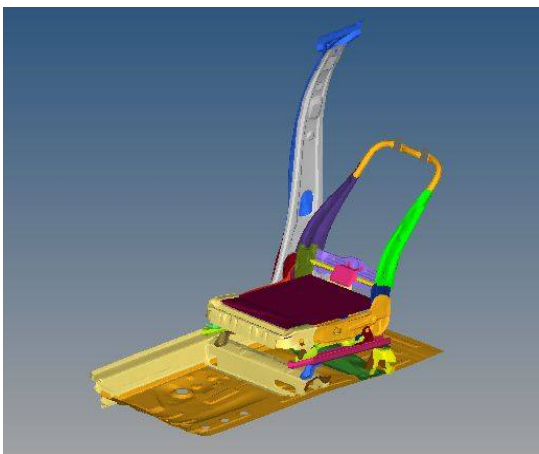


Figure 2.1 CATIA Model of seat

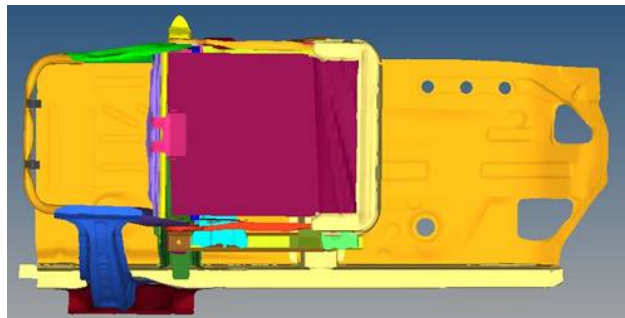


Figure: 2.2 Top view of seat model

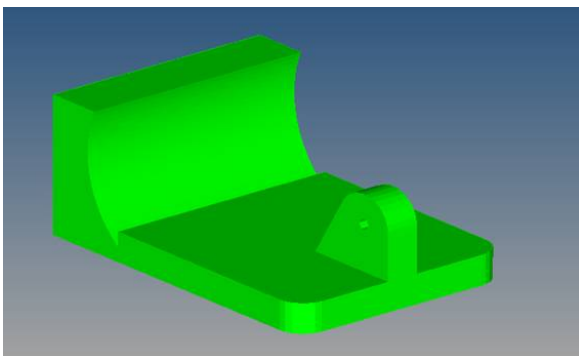


Figure 2.3 Lap Block Anchorage

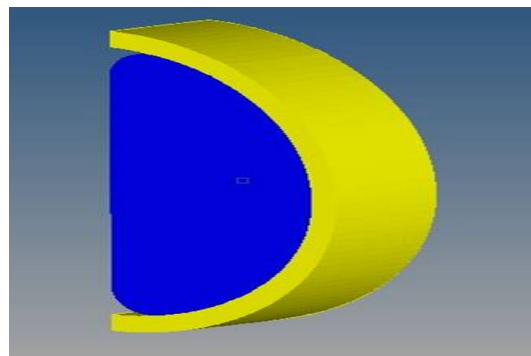


Figure 2.4 Shoulder Block

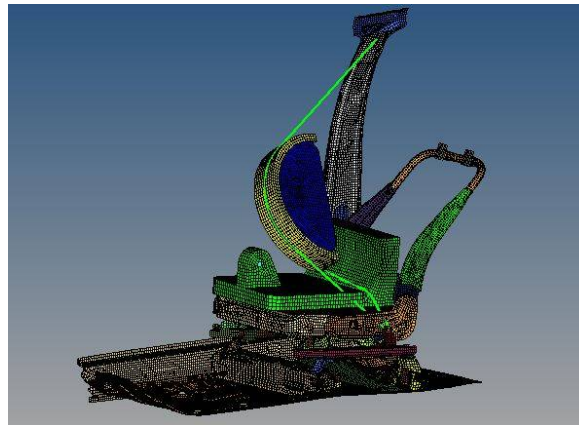


Figure 2.5 FE Model of seat

### III. RESULTS AND DISCUSSION

#### Baseline Simulation-Iteration-I:

The results from LS-Dyna3D analysis for a seat belt pull up-to 70 milli seconds is presented in this chapter. It can be seen that the seat block and the floor do undergo significant deformation during the pull.

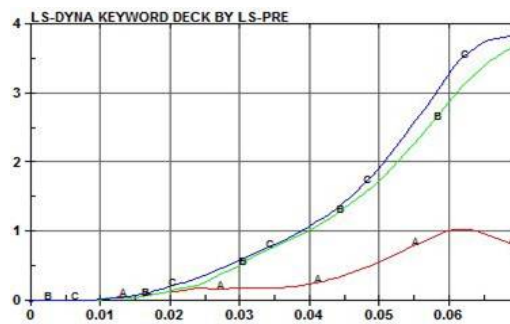


Figure 3.1 Base simulation

Figure 3.1 above shows the variation of the kinetic, potential and total energy for the specific case of seat belt pull considered in the present study. As can be seen the kinetic energy is converted to internal energy of the block. As expected kinetic energy starts decreasing with increase in internal energy and total energy remain constant. The below table 3.1 gives the curve name along with their name.

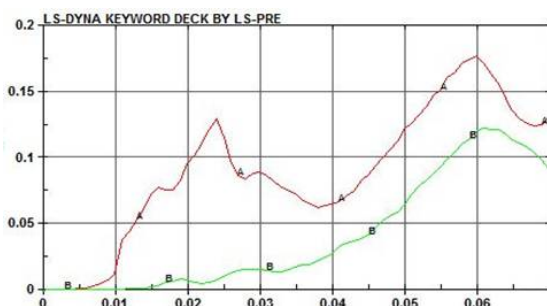


Figure 3.2 Variation of kinetic energy of body block

Curve	Energy
A (Red)	Kinetic Energy
B (Green)	Internal Energy
C (Blue)	Total Energy

Table 3.2 Different types of energy curves

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The above figure 3.2 represents the variation of kinetic energy of body blocks during the simulation. The below table 6.2 gives the curve with their component name.

Curve	Component Name
A	Lap block
B	Body block

The variation of the kinetic energy represented above shows the load that is applied on the body blocks during the simulation, where the load applied on the body blocks will be transferred to the different components of seat.

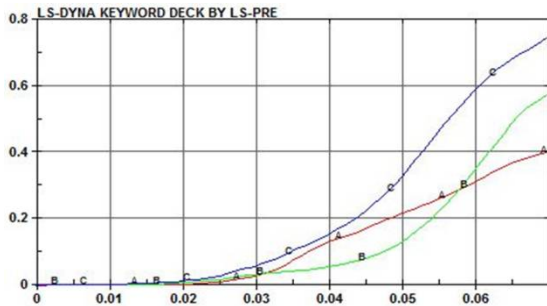


Figure 3.3 Name of the curve with the component name

Curve	Component Name
A	Floor mount
B	Rocker panel
C	B-pillar (Inner)

Table 3.3 Different types of curves

The Internal energy of different components of seat which absorb the impact energy is as shown in figure 6.4. The below table 6.3 gives the name of the curve with their component name. As shown in figure 6.4. Maximum amount of energy is absorbed by B-Pillar (curve-C) where the seat is attached. A significant amount of the impact energy is also absorbed by floor (curve-A), where the seat is attached by using floor mount. A part of energy is also absorbed by Rocker panel (curve-B), which runs along the length of the floor.

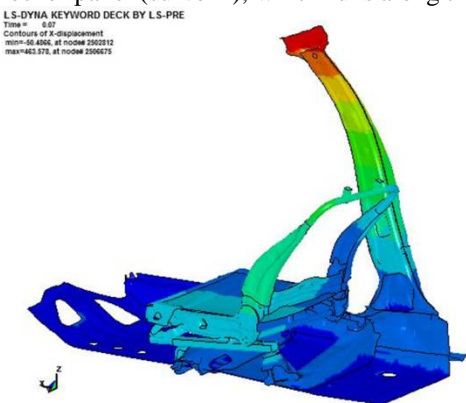


Figure 3.4: Displacement Values from the Baseline Run

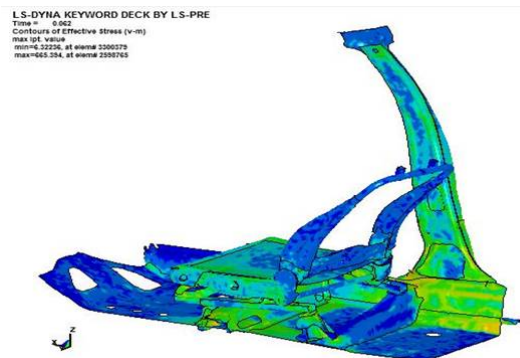


Figure 3.8 Von Mises stress contour

From the above figure 3.4 it is seen that the maximum displacement of the seat for the baseline run is around 463.5 mm near B-pillar. The displacement of point A on B-pillar during simulation is as shown in below in figure 3.7.

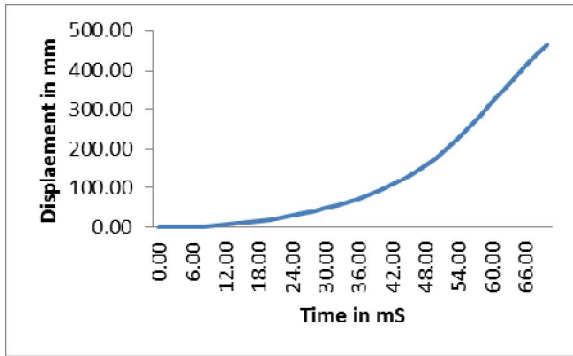


Figure 3.7 B –Pillar simulation

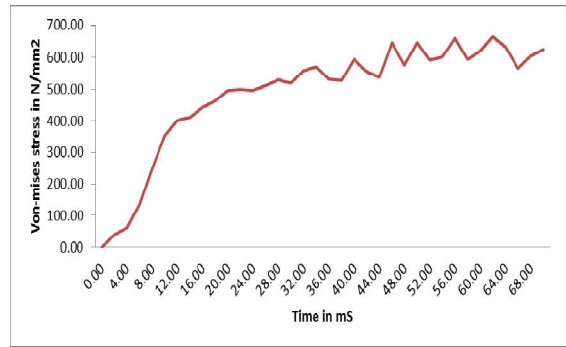


Figure 3.9 variation of von mises stress

The above figure 3.9 shows the variation of von-Mises stress during simulation. It is found to be maximum at 62 milli seconds near the B-pillar. In the second iteration a trial is made to replace the material from general steel to high strength steel. The material property and the stress strain curve after the yield point are as shown above.

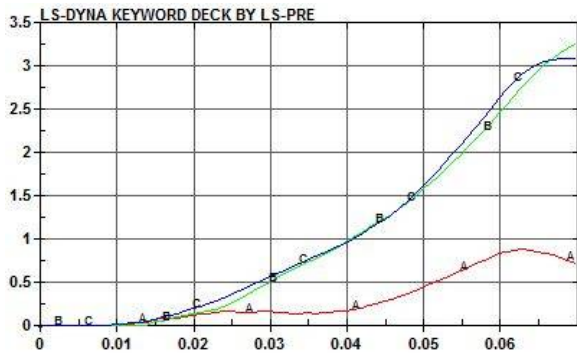


Figure 3.10 Energy Plot

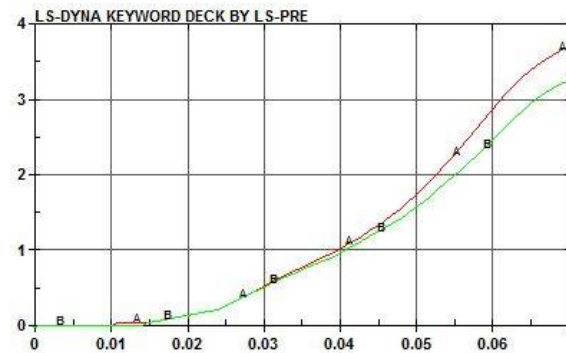


Figure 3.11 Energy Plot

**Kinetic Energy of Body Blocks**

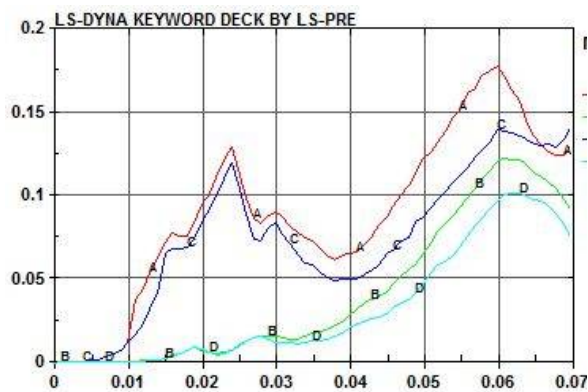


Figure 3.12 Energy Plot

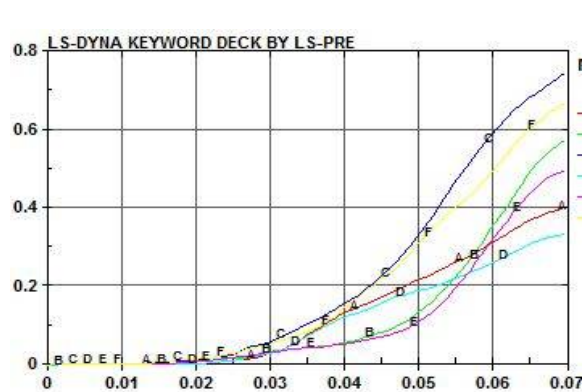


Figure 3.13 Energy plot

Figure 3.10 above shows the variation of the kinetic, potential and total energy for the specific case of seat belt pull using high strength steel. As can be seen the kinetic energy is converted to internal energy of the components. As

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expected kinetic energy starts decreasing with increase in internal energy and total energy remain constant. The table below gives the name of the curves along with their colour. The energy absorbed using the high strength steel as an option is much higher than that by using conventional steel. The above figure 3.11 represents the global internal plot for the case of general steel (red curve) and high strength steel (green curve). Since the displacement in case of high strength steel in iteration II is less than that for the conventional steel in iteration I, the internal energy is reduced. Hence it is expected that the ultimate ‘g’ forces acting on the occupant also is therefore reduced. The above figure 3.12 represents the variation of kinetic energy of body blocks during the simulation for iteration-I and iteration-II. Where curve A, C represents the kinetic energy for iteration-I and curve B, D represents the kinetic energy for iteration-II. Since the displacement in case of high strength steel in iteration II is less than that for the conventional steel in iteration I, the kinetic energy coming on the block is reduced. The below table 6.6 gives the component with their curve name.

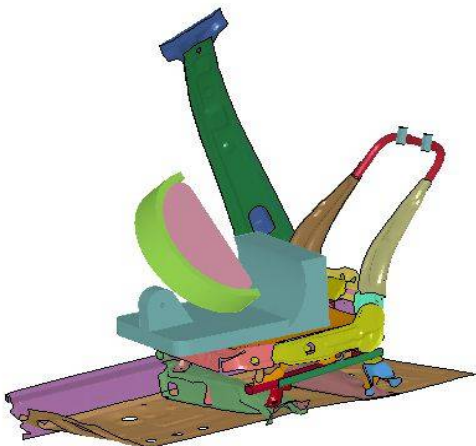


Figure 3.13 Internal energy simulation

Curve	Component Name
A, D	Floor mount
B, E	Rocker panel
C, F	B-pillar(Inner)

Table 3.4 Energy curve for different component

### Displacement of B-pillar For Iteration II

The displacement of point A on B-pillar for iteration II is as shown in figure 3.13 above. The contours of displacement and actual graph of the magnitude of displacement v/s time at point-A during crash simulation is shown in figure 3.14 below.

### Displacement Contour for Iteration II

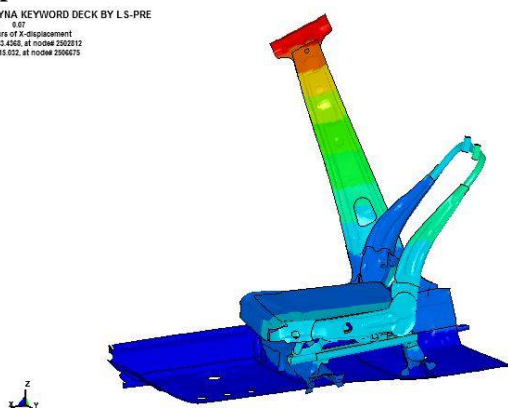
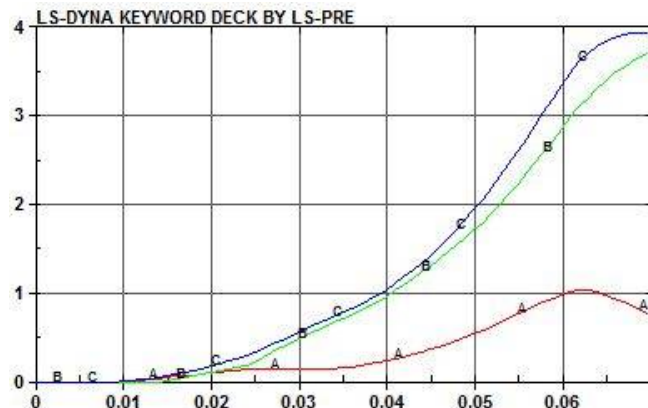


Figure 3.14 Von mises stress simulation



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### Von Mises Stress Contour for Iteration-II:

The maximum value of the von Mises stress is observed to be 938.3 N/mm<sup>2</sup> and it is near the bottom end of the B-pillar. Von-Mises stress during simulation for iteration-I and iteration-II is observed that the stress levels are higher for the case of high strength steel (red curve) compared to general steel (blue curve).

### Global Energy Plot

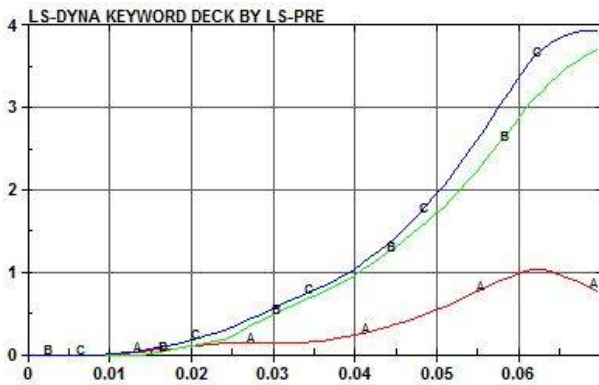


Figure 3.15 Energy Plot

Curve	Energy
A (Red)	Kinetic Energy
B (Green)	Internal Energy
C (Blue)	Total Energy

Table 3.5 Energy Curve

Figure 3.15 above shows the variation of the kinetic, potential and total energy for the specific case of seat belt pull using aluminium. As can be seen the kinetic energy is converted to internal energy of the block. As expected kinetic energy starts decreasing with increase in internal energy and total energy remains constant. The below table 3.5 gives the curve name along with their name.

### Displacement of B-pillar For Iteration III

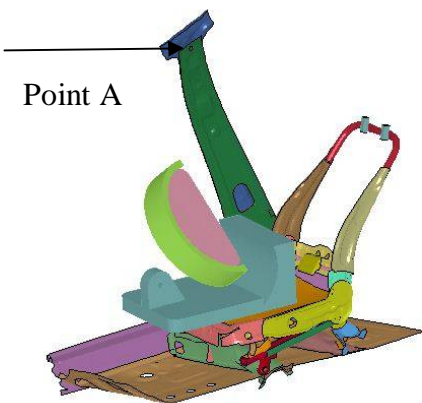


Figure 3.16 B – Pillar

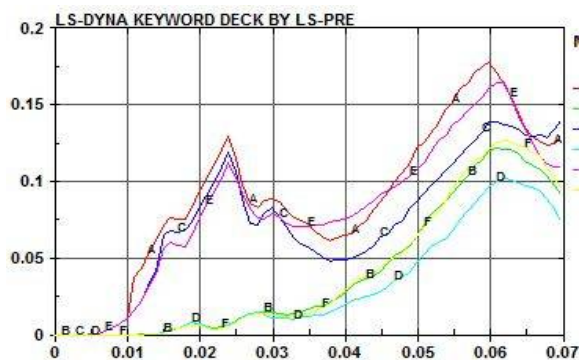


Figure 3.18 Kinetic energy of body block

### Displacement Contour for Iteration III

It is seen that the maximum displacement of the seat for iteration-III is around 454 mm at B-pillar. This is less compared to 463 mm at the same point using the conventional or general steel material. The above figure 6.29 represents the displacement of B-pillar during simulation for the case of general steel (red curve), high strength steel (green curve) and for the case of aluminium. And it can be seen that the displacement for the case of general steel is more compared to high strength steel. Displacement for the aluminium case is slightly less than that for general steel.

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### Von-Mises Stress Contour for Iteration-III:

The von-Mises stress contour for this analysis is shown in figure 6.30 above. The maximum value of the von-Mises stress is observed to be 634.7 N/mm<sup>2</sup> and it is near the bottom end of the B-pillar. The above figure 3.18 represents the variation of kinetic energy of body blocks during the simulation for iteration-I and iteration-II and iteration-III. Where curve A, B (red and green) represents the kinetic energy for iteration-I, the curves C, D (dark blue and navy blue) represents the kinetic energy for iteration-II and the curves E, F (purple and yellow) represents the kinetic energy for iteration-III. Since the displacement in case of high strength steel in iteration II is less than that for the conventional steel in iteration I, compared to these two cases the kinetic energy coming on the block is good in case of iteration-III

### Internal Energy

The below figure 3.18 shows the plot of internal energy of different components of seat for iteration-I and iteration-II. Where curve A, B, C represents the internal energy for iteration-II, the curves D, E, F represents the internal energy for iteration-I and the curves G, H, I represents the internal energy for iteration-III

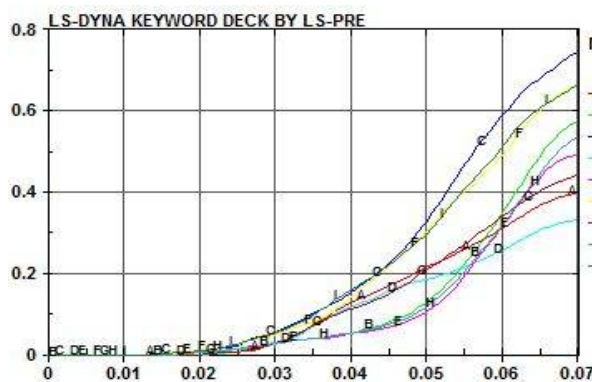


Figure 3.18 Internal energy curve

## IV. CONCLUSION

### Global Energy comparison

#### Kinetic Energy:

Kinetic energy of general steel and aluminium is similar in magnitude and the kinetic energy of high strength steel is slightly less in magnitude. This shows that the impact energy applied on the seat for testing is slightly higher for general steel and aluminium as compared to that applied on high strength steel.

#### Internal Energy:

Internal energy of general steel and aluminium is almost same compared to high strength steel, The analysis results indicate that the internal energy absorbed by the seat model using the high strength steel as the material is more compared to seat model using general steel and aluminium material.

#### Kinetic Energy of Body Blocks

The body blocks represent human chest portion (shoulder block), and pelvic region (lap block). Hence, the body blocks play a important role in transforming the externally applied loading to the different components of seat structure.

From the analysis in this project, it is observed that the kinetic energy of body blocks for the case of the model using aluminium as the material is better compound to general steel and HSS. This can be expected as the specific energy absorption capability of Aluminium is generally more than for corresponding steel.

#### Internal Energy of other major energy absorbing members of the seat assembly

The following are the other major energy absorbing members of the seat assembly. In particular maximum amount of energy is absorbed by the components mentioned below along with their material ID

1. B-pillar (200309) - Where the seat belt is connected
2. Rocker panel (200297) -Which connects floor & B-Pillar

Comparison of energy absorbed by components mentioned above indicate the following:

**B-pillar** – For this particular component high strength steel is absorbing more energy compared to general steel and



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aluminium as shown in figure 6.24. Internal energy absorbed by general steel and aluminium are of similar magnitude.  
**Rocker panel** - For this particular component general steel is absorbing more energy as compared to aluminium and high strength steel stands in that order.

**Floor cross member** - For this particular component general steel is absorbing more energy followed by aluminium and high strength steel in that order.

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