DECKSETUP OF A CAR MODEL ALONG WITH DOOR IMPACT

Dr. B. Ravi Associate Professor, Department of Mechanical Engineering, Swarna Bharathi Institute of science & Technology, Khammam, TS- 507002, India.
Dr. G. Raja Kumar Professor, Department of Mechanical Engineering, Swarna Bharathi Institute of science & Technology, Khammam, TS- 507002, India
Email id's: bravi1234@gmail.com, rajkumardotcom@yahoo.com

Abstract

The finite element method provides a powerful procedure to mathematically model physical phenomena. The technique is numerically formulated and is effectively used on a broad range of computers. The method has increased in both popularity and functionality with the development of user friendly pre- and post-processing software. Pre-processing software is used to create the model, generate an appropriate finite element grid, apply the appropriate boundary conditions, and view the total model. Post-processing provides visualization of the computed results. This paper addresses the pertinent issues of pre- and post-processing for finite element analysis. It reviews the capabilities that are provided by pre- and post-processors and suggests enhancements and new features that will likely be developed soon. Car door is one of the main parts which are used as protection for passengers from side collisions. Side impact collision of vehicle is one of the terribly hazardous crashes causing injuries and death annually around the word. In the side impact, the side door is responsible for absorbing the most possible kinetic energy. Presently steel is used for car doors construction. The aim of the paper is to analyse the car door and its structure with currently used material by replacing it with dual phase steel. Impact analysis is conducted on door with Dynamic analysis using LS Dyna software.

Keywords: LS Dyna software, kinetic energy, ANSYS Fluent, hazardous crashes, Dynamic analysis.

Introduction

Deck setup of a Car model means modelling a Car model for doing any type of analysis like Frontal crash, Rear crash, Side impact, Roll over analysis etc. in any Simulation software. A side impact car accident occurs when one vehicle hits another vehicle on its side. This type of collision can occur head-on or at an angle. Due to the devastating vehicle damage that side impact collisions can cause, many of these accidents result in severe injury or even death.A side collision is a vehicle crash where the side of one or more vehicles is impacted. These crashes typically occur at intersections, in parking lots, and when two vehicles pass on a multi-lane roadway. Side collisions are where the side of one vehicle is impacted by the front or rear of another vehicle, forming a "T". Vehicle damage and occupant injury are more likely to be severe, but severity varies based on the part of the vehicle that is struck, safety features present, the speeds of both vehicles, and vehicle weight and construction. When a vehicle is hit on the side by another vehicle, the crumple zones of the striking vehicle will absorb some of the kinetic energy of the collision. The crumple zones of the struck vehicle may also absorb some of the collision's energy, particularly if the vehicle is not struck on its passenger compartment. Both vehicles are frequently turned from their original directions of travel. If the collision is severe, the struck vehicle may be spun or rolled over, potentially causing it to strike other vehicles, objects, or pedestrians. After the collision, the involved vehicles may be stuck together by the folding of their parts around each other. An occupant on the struck side of a vehicle may sustain far more severe injuries than an otherwise similar front or rear collision crash. Side-impact airbags can protect vehicle occupants during side collisions, but they face the same limitations as other airbags. Additionally, side impact wrecks are more likely to involve multiple individual collisions or sudden speed changes before motion ceases. Since the airbag can only provide protection during the first collision, it may leave occupants unprotected during subsequent collisions in the crash. However, the first collision in a crash typically has the most severe forces, so an effective airbag provides maximum benefit during the most severe portion of a crash.

Statement of the Problem

Side impact collision accidents happen every day in various countries are mostly dangerous stage condition leads to death. Moreover, the space required of the side impact is less than the frontal impact. Side impact collision is directly impacted by the structure of a vehicle which affects the occupant. The vehicle structure which absorbs the impact energy from the side impact which passes the limited injuries to the occupant from the accident and side impact beam should resist from the crash impact forces, absorb the energy which minimizes the impact to the passenger compartment.

Objectives of the study

- The impact beam is attached on the door panel of the vehicle which has strengthened the car door for safety and side impact beam should be a high static strength, stiffness is a most important factor for the collision impact.
- Many car companies, manufacturing the vehicle structure of the door with standard regulation which concerns the weight reduction, high stiffness, high toughness and absorbs the deformation energy.
- They are two techniques to reduce the mass of the side impact beam, the first technique is to redesign cross-section of the beam and second technique is to change the materials of the beam like aluminum alloy, mild steel, and composite material. This method is generally very useful to the lightweight automobile impact beams and body structures of the vehicle.

Review of Literature

Yuzhuo [1] studied on the dispersion of carbon monoxide (CO) in vehicular exhaust plumes using two computational methods: Lattice Boltzmann Method and Large Eddy Simulation.The results show that both methods are effective in predicting the CO concentration and dispersion characteristics**. Chao [2]** presents a detailed multi-fluid lattice Boltzmann scheme for modeling reacting multi-species flows, which is capable of simulating complex chemical reactions with high accuracy and efficiency. The proposed scheme is validated through several benchmark tests and demonstrates superior performance compared to existing methods. **Yifan [3]**presented a field investigation to estimate the exposure of pedestrians and drivers to vehicle exhaust during idling and starting conditions. The investigation was conducted in a busy urban area, and measurements were taken at different distances from the vehicles. **Sawant [4]**proposed a consistent lattice Boltzmann model for simulating multicomponent mixtures that includes a new approach for handling interactions between different components. The proposed model is validated through several benchmark tests and is shown to be more accurate and efficient compared to existing methods. **Ning [5]** presented an experimental and numerical study on the dispersion of motor vehicle pollutants under idle conditions. The investigation was conducted using a full-scale vehicle and a wind tunnel, and the results show that the pollutant dispersion is highly dependent on wind speed and direction. The study also uses a computational fluid dynamics model to simulate the pollutant dispersion. **Chikatamarla [6]** presents a lattice Boltzmann method (LBM) for direct numerical simulation of turbulent flows. The proposed method uses a single-relaxation-time collision model and is capable of simulating turbulent flows with high accuracy and efficiency. The method is validated through several benchmark tests and is shown to be capable of capturing important features of turbulent flows, including the development of turbulence statistics and the energy spectrum. **Owen [7]** in his paperpresents a high-order adaptive algorithm for simulating multispecies gaseous flows on mapped domains. The algorithm uses a combination of a high-order finite volume method and a high-order adaptive mesh refinement technique to efficiently capture complex flow features while minimizing computational costs.

Research Methodology

The finite element method (FEM) is a numerical technique for solving problems which are described by partial differential equations or can be formulated as functional minimization. A domain of interest is represented as an assembly of finite elements. Approximating functions in finite elements are determined in terms of nodal values of a physical field which is sought. A continuous physical problem is transformed into a discretized finite element problem with unknown nodal values. For a linear problem a system of linear algebraic equations should be solved. Values inside finite elements can be recovered using nodal values. Two features of the FEM are worth to be mentioned. Meshing is one of the most important steps in performing an accurate simulation using FEA. A mesh is made up of elements which contain nodes (coordinate locations in space that can vary by element type) that represent the shape of the geometry is shown in figure 1.

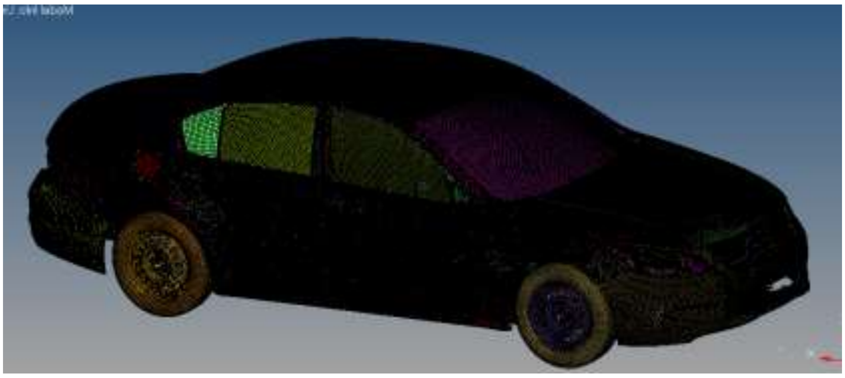

Figure 1: Ansys Fluent Workbench

Results:

We have to assign thickness for all the elements in the model. All shell elements include membrane, bending and shear deformation. While assigning material properties, we need to specify the input material parameters like Element Formulation (ELFORM), Thickness of the component, Number of Integration Points(NIP) etc are shown in fig 2 & 3.

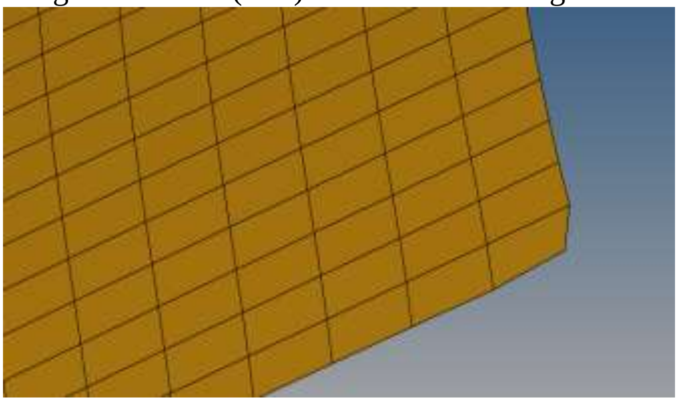

Figure 2: Before Assigning Properties.

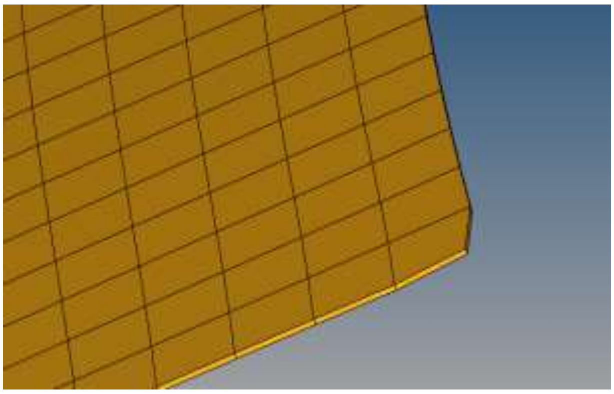

Figure 3: After Assigning Properties.

Penetration is defined as the overlap of the material thickness of shell elements, while intersection is defined as elements passing completely through one another. It is always recommended to remove the intersections and penetrations before the run. These could result in weird behavior of the model. Assigning Loads, Boundary conditions and Contacts need to be done while doing analysis. LS-DYNA is used for the analysis of the Hypermesh model. But, LS-DYNA needs the input parameters to run the solution.

Contacts: Contact is given to detect the components. So, the contacts are given at the mating parts. *CONTACT_AUTOMATIC_SURFACE_TO_SURFACE is given between the Door component and Rigid body. The contact is shown in the figure 4.

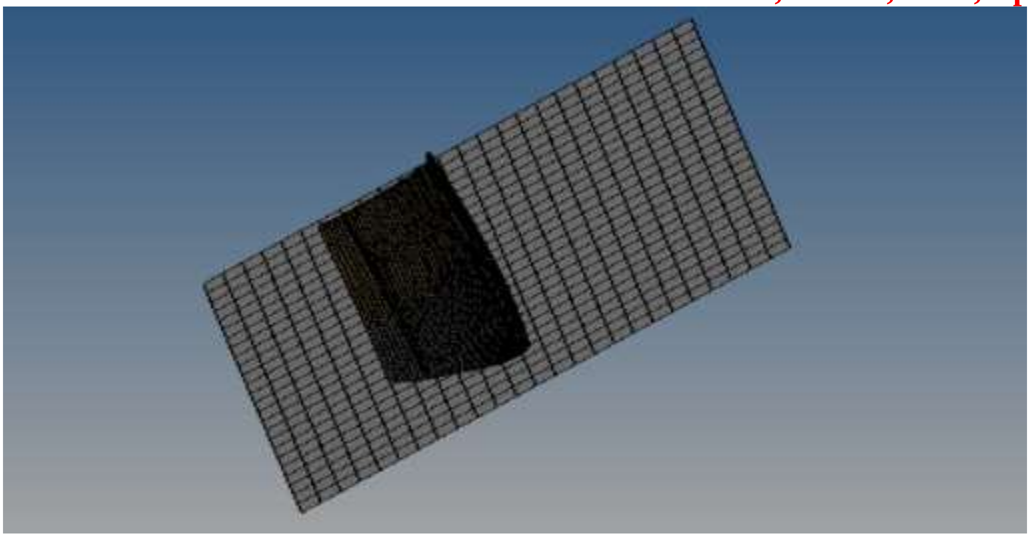

Figure 4: Load conditions

LOADS: Load is assigned to the Door component in the form of velocity as shown in Fig 4. *INITIAL_VELOCITY_GENERATION is used to give the velocity to the doors of a vehicle. For rigid body or barrier, we no need to give any loads, as is is fixed member which has no deformation. Velocity of the door is given as 2 m/s.

Boundary Conditions: Boundary conditions is assigned to the rigid wall or barrier. It has zero Degree of freedom (DOF) and has no deformation also. *BOUNDARY_SPC_SET is used to fix the rigid body.

Control cards: CONTROL_TERMINATION is given to specify the end time. End time is as 25min in this project. These cards are used control the analysis in the software.

Database cards: Database cards is used to get the output energy curves. Kinetic energy curve and internal energy curve is given in the database cards to get the output energy graphs.

Results And Discussion

We have used two different types of materials for the analysis of the side impact of a Car. Steel and Aluminium-Magnesium alloy is used as a Door material in two cases of same load. The values of the deformation, stress, effective plastic strain and energies graphs are obtained as follows and are shown in figures 5-10.

Results obtained while Steel material is used for Doors:

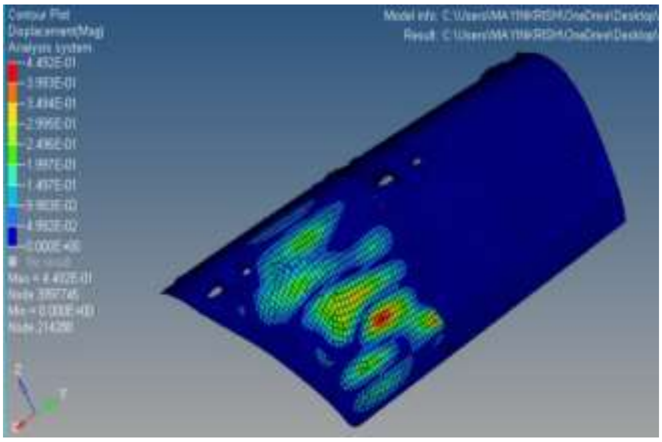

Figure 5 Displacement in Steel material after impact.

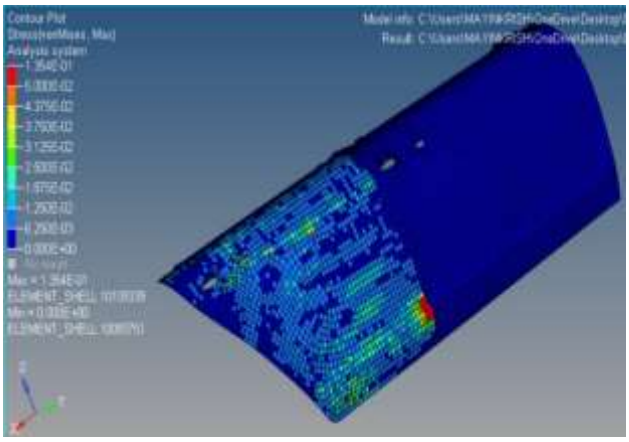

Figure 6 Stresses in Steel material after impact.

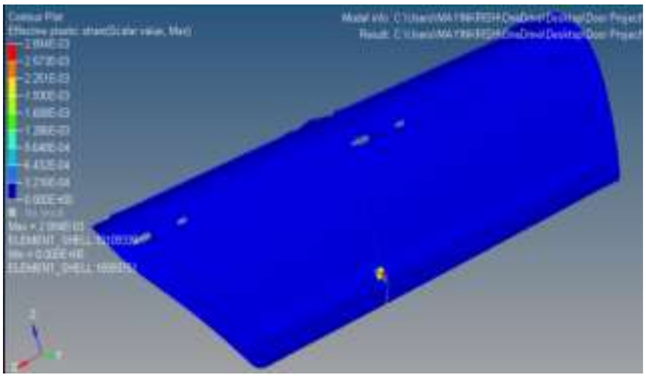

Figure 7 Effective Plastic Strain for Steel material after impact.

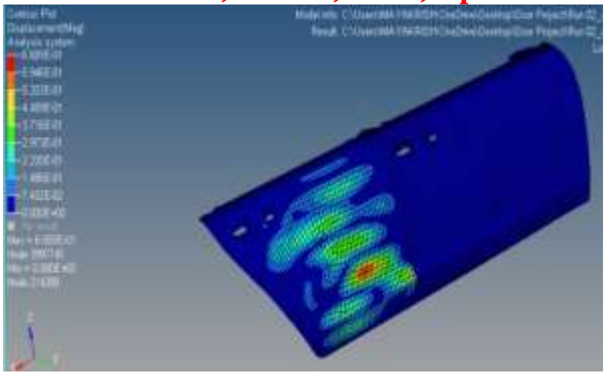

Figure 8 Displacement in Al-Mg material after side impact.

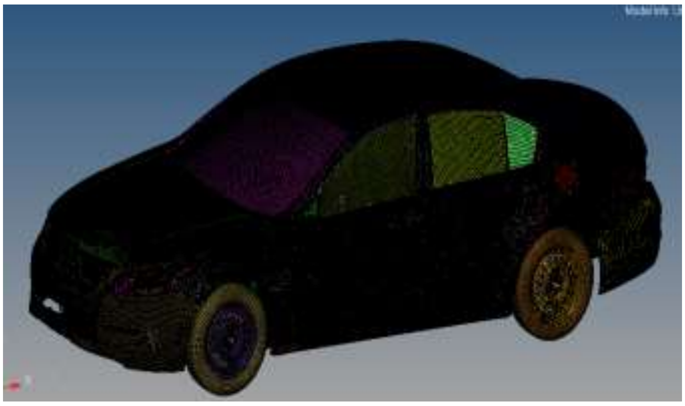

Fig. 9 Deck setup of Car model – Shaded view.

Fig 10. Deck setup of Car model –Wire frame.

The internal energy obtained in the side impact of a Car by using Steel material for Car door is shown in the figure below. Internal energy is minimum before impact occurs at 0 J. It went to 180 J at the time of impact. After impact, again the internal energy went to the minimum value of 0 J as shown in figure 11 and table 1.

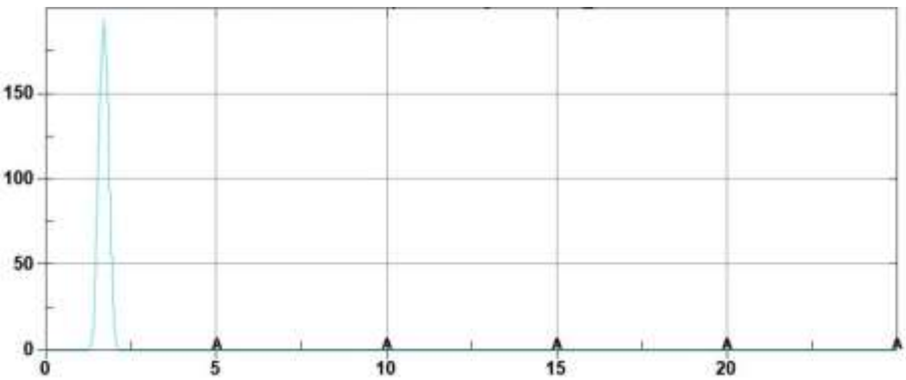

Figure 11 Internal energy (on Y-axis) vs Time (on X-axis) for Al-Mg material.

Time (sec)	Kinetic energy (Joules)
0	0
2	180
4	0
6	0
10	0
15	0

Table 1 Kinetic energy with respect to time for Al-Mg material.

Conclusion:

As a conclusion, side door impact beam is one of the structures that is responsible to absorb kinetic energy and reduce door intrusion to the occupants when a vehicle is involved in side impact collision. Accordingly, it should be sufficient to withstand the impact loading. Hence, the component needs to have high strength to prevent the passenger compartment from being compromised and it also needs to be ductile to prevent the intrusion to the passenger's compartment. To that end, extensive research on the combination of types, materials, and joints of side door impact beam should be conducted properly by engineers to avoid injuries and fatalities to the occupants. This will reduce the statistics of fatality in side impact collision.

References

1. Yuzhuo Men, Yuyang Lai, Suzhen Dong, Xin Du , Yihan Liu,"Research on CO dispersion of a vehicularexhaust plume using Lattice BoltzmannMethod and Large Eddy Simulation", Transportation Research Part D: Transport andEnvironment,Volume 52, Part A, Pages 202-214, May 2017.
2. Chao NING, Shouqi YUAN, Jinfeng ZHANG, and YalinLI,"Modeling Reacting Multi-Species Flows with a Detailed Multi-Fluid Lattice Boltzmann Scheme", vol.25, No.1B, Pages691-704,2021
3. Yifan Ding, Xuanpeng Zhao, Ji Luo, Guoyuan Wu, AkulaVenkatram,"Field study to estimate exposure to vehicle exhaust during idling and starting",Turkish National Committee for Air Pollution Research and Control,Atmospheric Pollution Research 14 (2023) 101632
4. N. Sawant, B. Dorschner, I. V. Karlin,"Consistent lattice Boltzmann model formulticomponent mixtures", J. Fluid Mech. (2021), vol. 909, A1. © The Author(s), 2020, Published by Cambridge University Press. doi:10.1017/jfm.2020.853

5. Z.Ning, C.S.Cheung, Y.Lu, M.A. Liu, W.T. Hung, "Experimental and numerical study of the dispersion of motor vehicle pollutants under idle condition",AtmosphericEnvironment,Volume 39, Issue 40,December 2005, Pages 7880-7893

6. S.S.Chikatamarla,C.E.Frouzakis, I.V.Karlin, A.G.Tomboulides, K.B.Boulouchos,"Lattice Boltzmann method for direct numerical simulation of turbulent flows",Cambridge University Press: 08 July 2010.
7. L.D. Owen, S.M. Guzik, X. Gao "A high-order adaptive algorithm for multispecies gaseous flows onmapped domains", Department of Mechanical Engineering, Colorado State University, Fort Collins, CO 80523, USA, May 2018.