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Design, Analysis and Optimization of Car Door

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Abstract: ***The main aim of this project is the design, analysis and optimization of car doors. The car door is one of the essential parts of the vehicle, made of plastic, steel, and aluminum materials. Safety is a concern for automobile users due to the number of accidents happen and the increase the number of car users. The car door protects the passenger from external impact. The energy-absorbing capacity of the door has the potential to reduce the impact of the door. Automobile industries have been focused on the optimization of doors and increasing the efficiency of the vehicle. The impact analysis is done with a falling steel ball as per the specification, and the crashworthiness is studied. Improve the design until we get the best result for improving the safety of the door design. This analysis reduces the damage to cars and protects passengers. This analysis reduces the impact by 10%. The design of the car door is done using CATIA. Our problem statement focuses on side-impact analysis using software tools like Hypermesh and LS-Dyna.***

Keywords: ***Car door, Finite element Analysis (FEA), Impact Analysis, optimization, deformation.***

I. INTRODUCTION

The carmaker launches new vehicles with more features, using different materials, and optimizing the car using various software programmers. The consumer likes the safest car and best looking efficient car this is the challenge for engineers [1-2]. Advanced cars come with comfort, safety, and security parameters, various sensors, an infotainment system, a sound system, and other safety parameters [3-4]. The crashworthiness is sustained impact at the time of the accident. Impact crash testing is the maximum damage to the vehicle [5-6]. The accident happens at that time the damage depends on how much energy is absorbed by the structure because there is no space for the transfer of energy. The side impact test and front impact test are the most dangerous crash tests, which injured the passenger [7-8].

The car door is attached to the car body by one end. In a car, there are typically two types of doors. One door is operated manually, and another is powered electronically. The electrically operated door is basically used in expensive cars. The exterior side of the car door is made of steel, while the interior side is made of plastic, fabric, and decorative material for aesthetic purposes [9-10].

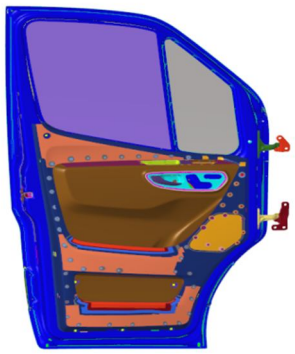


Fig.1.1 Assembly of Car door.

The material used from the outside has been considered the safety purposes and the material used for the inside purpose is only for great looking. Inside material consider to the match of the instrument panel, carpet, and other inside parts and purpose of feeling good. Car door is important part because of easy access of passenger to come inside and car door protect the passenger from side impact. This paper mentions the Importance of door and its material studied to improve the crashworthiness during crash [11-12].
HyperMesh Modelling Software is used for: • Tetra Meshing. • Hex Meshing. • Shell Meshing. • Mold flow Meshing. • Midsurface Mesh.

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II. LITERATURE REVIEW

Previous studies The researcher shows that they have used different materials for car doors like plastic, steel, and aluminum. It absorbs impact energy. Impact analysis improves crashworthiness during an accident. This material has very high energy absorbing and damping properties. Car doors are basically designed and manufactured to absorb more impact energy [1-4]. The old car used more steel material than the current vehicle, which increased the weight of vehicle. Automobile makers find out about the new composite material to balance the weight of the car door [5-7]. Composite material absorbs more energy as compared to steel material. The composite material has high strength, stiffness and improves the fuel efficiency of vehicles [8-10].

To change the material of the door part to get a better result and absorb more energy. This door is directly manufactured for the OEM, reducing the cost of prototypes. They have changed the design of plastic parts. Adding the additional ribs will absorb more impact energy in critical areas. The thermoplastic effect improves material properties and structural properties. The increase in the percentage of plastic and aluminum material reduces the 15 % weight of the door [11-12].

The researcher has analyzed finite element model for the human thorax to identify the impact of a car door. When the time of crash, the human thorax impacts the car door, check the effect of the car door.

III. METHODOLOGY

Following methodology has been adapted to carry out optimization of Car door.

1) Pre-processing
2) Solver process
3) Post-processing

Optimization Methodology

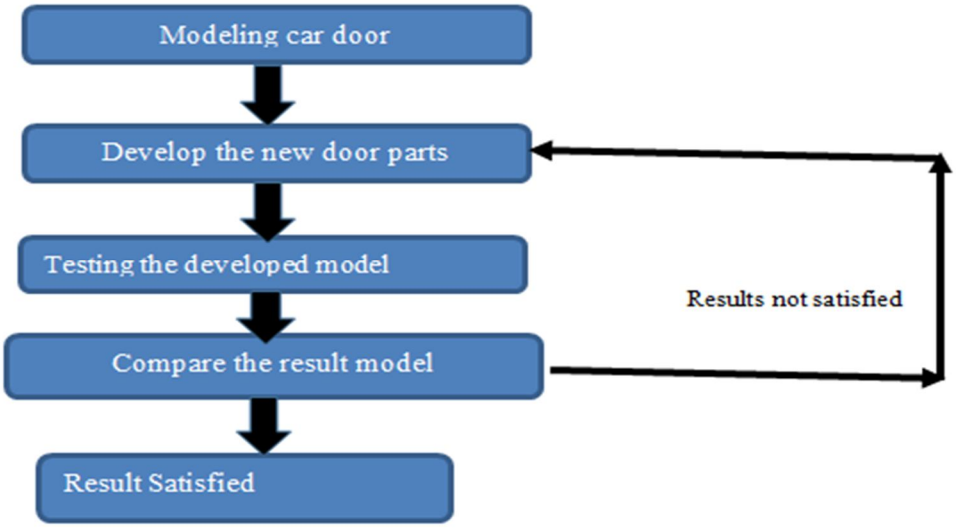


Fig.2. Flowchart of Car door design.

fig.2 shows the flowchart of car door design. In this flowchart include the methodology of modelling a car door and the satisfied results. When the results are not satisfied again starts the modeling of car door.

IV. ANALYSIS OF CAR DOOR

A. Pre-Processing

1) Import cad file
2) Meshing
3) Loading and Boundary condition

In the preprocessing, first import the CAD data and check the input of the CAD file. Check all duplicate surfaces and intersections, then create the midsurface of the model. Start the meshing as per the quality criteria. discretizing the model into a small number of elements using the finite element method. After completing meshing check the quality of the element.

Then apply the properties and materials. After applying loading and boundary conditions, check where the model is fixed and where the load is applied. Build up the model to know the required solution. After that, the simulation is carried out in simulation software. In car doors using plastic, aluminum and steel materials.

Material properties of plastic:

Material	Young's modulus (N/mm2)	Poisson's ratio	Density (Ton/mm3)
PPTD 20	2700.000	0.320	1.05e-09
STEEL	210000	0.300	7.85e-09
Aluminum	73000	0.330	2.70e-9

B. Post Processing

The postprocessing is the checking of the results for displacement, stress, energy. In postprocessing verify the result and take the required steps to improve the results. Hyperview software used for the post processing. In hyperview Import the solver output file and check the result.

C. Hypermesh

Hypermesh is the preprocessing modelling software used to build the model. In hypermesh, first import the CAD geometry, then after meshing, assign properties and materials, and lastly export the element. In the hypermesh, first need to define which mesh type is used: 1D, 2D, or 3D. As per requirement, we used 1D, 2D, and 3D mesh. Should take care about the number of elements because the system handles a limited number of elements.

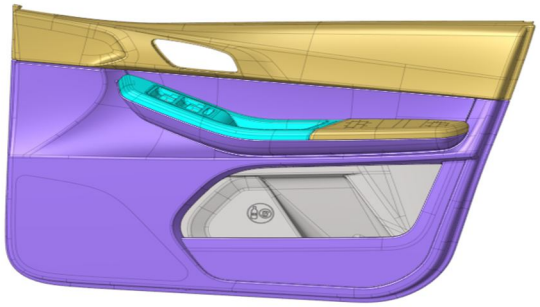


Fig.5.1 modeling of door trim

Meshing quality criteria for car door analysis:

In car door parts meshing size is 5 mm used. The element size is selected from the previous results. Using shell meshing and hex meshing and apply the below quality criteria to improve the results.

Quality parameters considered while meshing of door trim:

1) Warpage: warpage is deviates the node from its plane means one node goes to the outside of the plane to the rest of three nodes. Any plane defines the three nodes that why warpage check only the shell and hex elements. Warpage is used 13 mm
2) Maximum Angle: It is the angle between two edges of quad or tria element that is greater than acceptable limit. The maximum angle is used for tia 120 mm and quad 135 mm.
3) Minimum Angle: It is the angle between two edges of a quad or tria element that is less than the acceptable limit. The minimum angle used for tria is 25 mm and quad 35 mm.
4) Aspect Ratio: The aspect ratio is the ratio of the maximum length to the minimum length. The aspect ratio is always less than its acceptable limit. An aspect ratio is used 5 mm.
5) Jacobian: Changing element shape from a global coordinate system to a local coordinate system is called Jacobian. Jacobian is used at 0.6 mm.

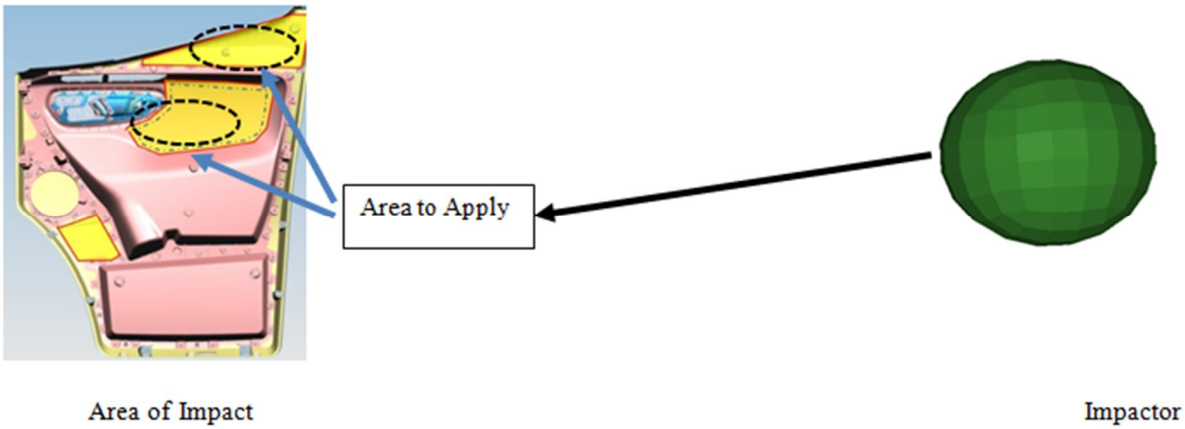


Fig.5.2 The area of impacts and Impactor.

Table 1. Specification of Impactor

Load - 10N
Actuator - Steel Ball 63mm Diameter - Height 1000mm
Location - On Picture
Max. Permanent Displacement - No Permanent Displacement
Open Gaps - Not Applicable
Biw Attachments Loads - No Detachment
Spotwelds Loads - No Detachment
Yielded Areas - No Yield Area
Breakage Areas - No Breakage

D. Apply load on the upper pocket area of car door

For impact test 10N load applied on upper pocket Area, Diameter of the impactor is 63 mm and velocity is 4429.44 mm/sec. Steel ball is dropped from height of 1000mm along global Y(-ve) direction at location shown in fig. 5.2. The fig. 5.2 shows that the area where maximum displacement is occurs. The red zone area shows more displacement due to dropped of steel ball. The fig.5.3 shows that the area where maximum stress is occurring due to dropped of steel ball. The red zone area shows more stress.

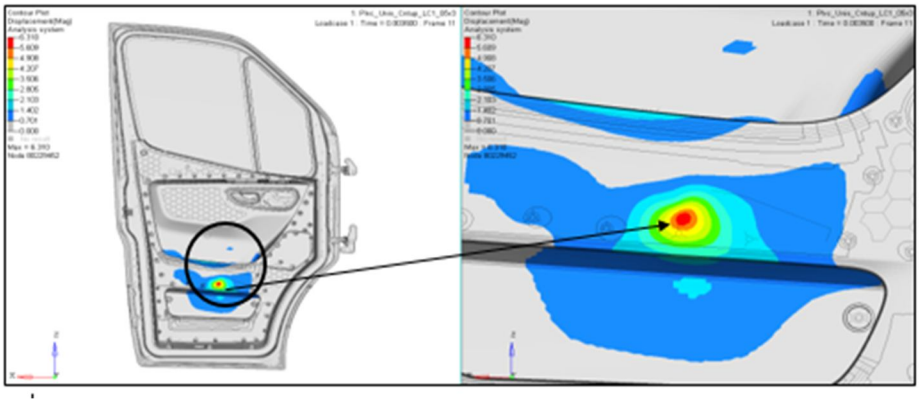


Fig.5.2 Max Displacement in upper pocket area.

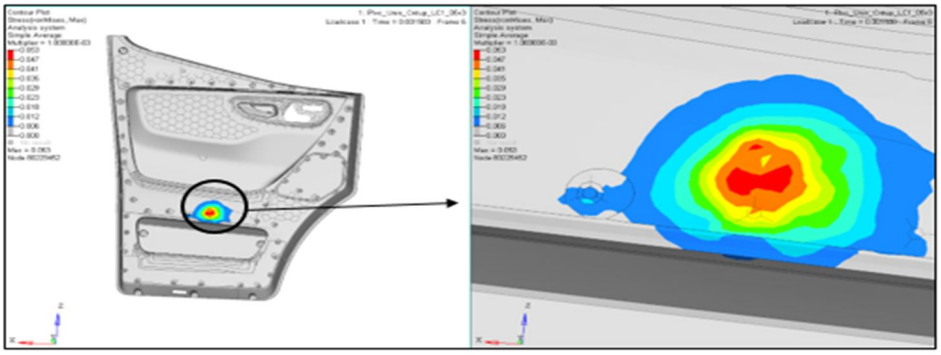


Fig.5.3 Maximum Stress in upper pocket area.

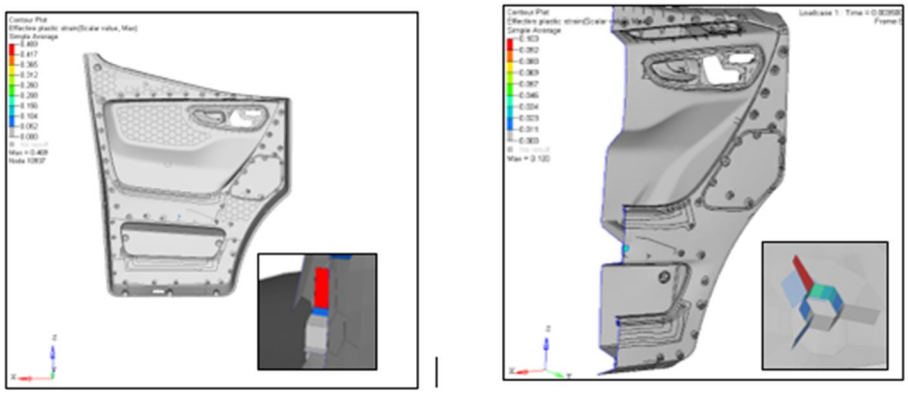


Fig.5.3 Maximum strain limit

E. Apply load on lower pocket Area of Car door

The fig.5.6 shows that the displacement of door lower pocket area. The red zone area shows maximum displacement. Fig.5.6 shows the stresses of door lower pocket area, the red zone area shows maximum stress.

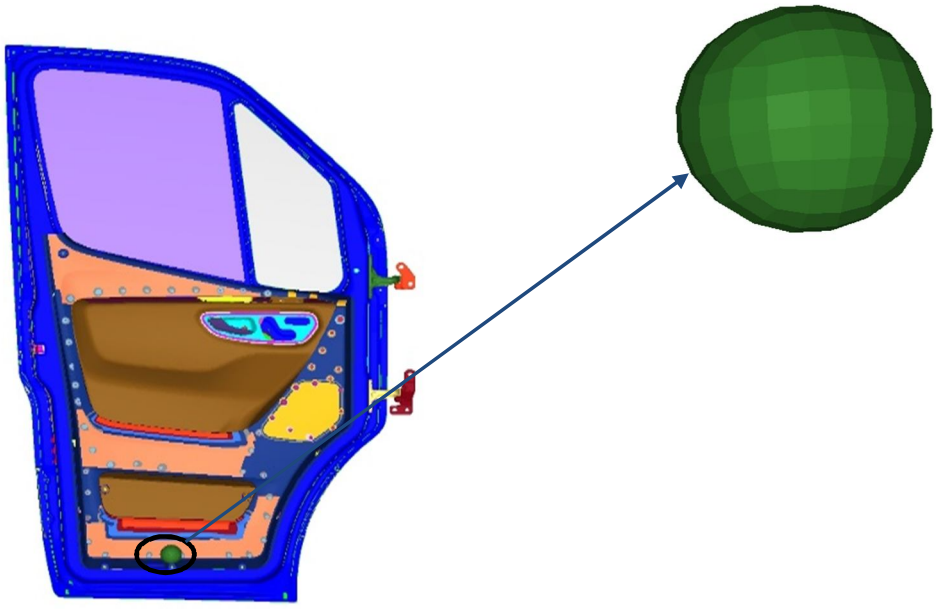


Fig.5.4 Area of Impact

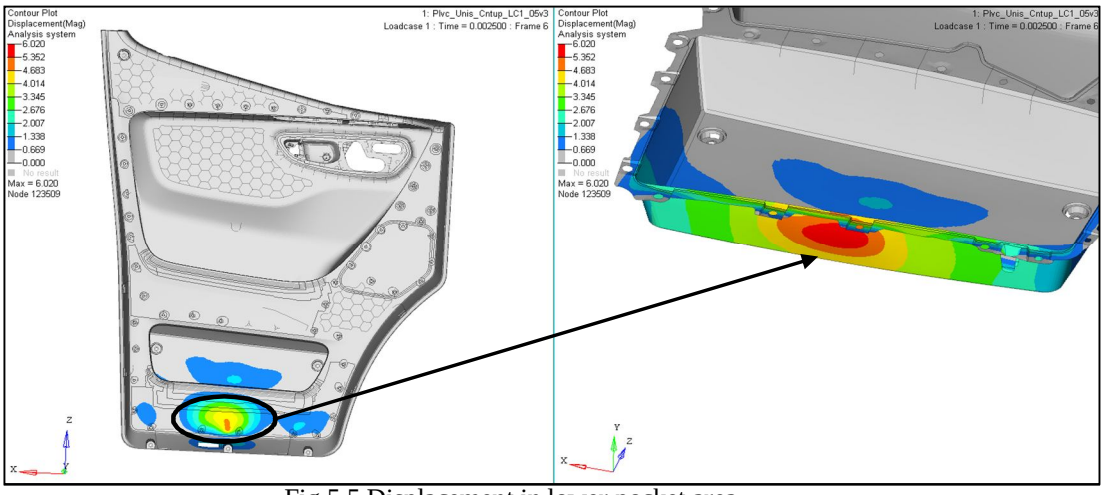


Fig.5.5 Displacement in lower pocket area

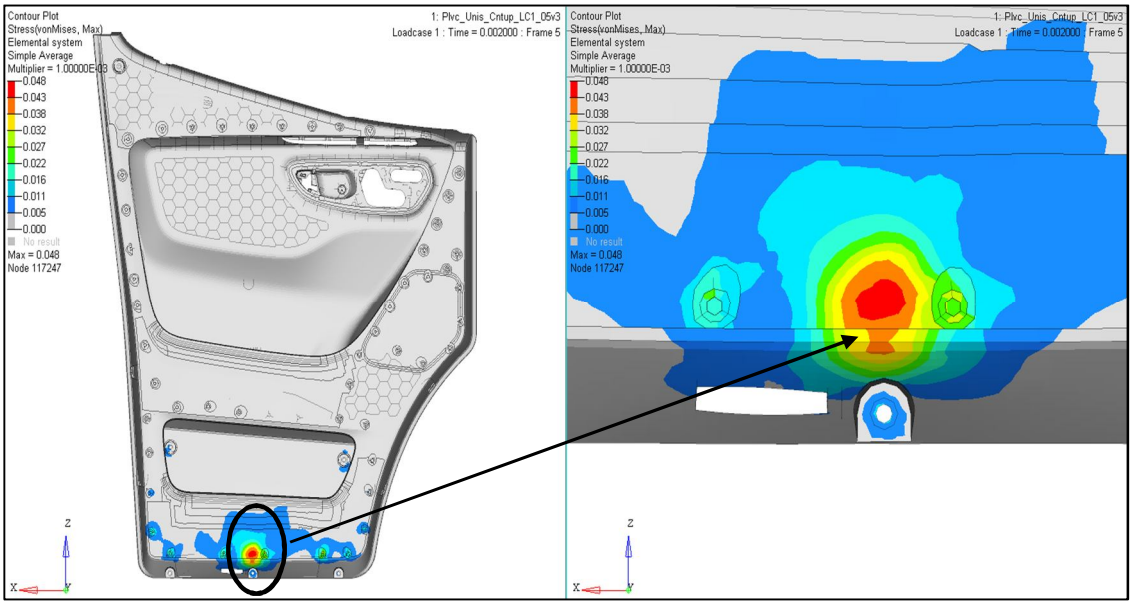


Fig. 5.6 Stresses of door lower pocket area

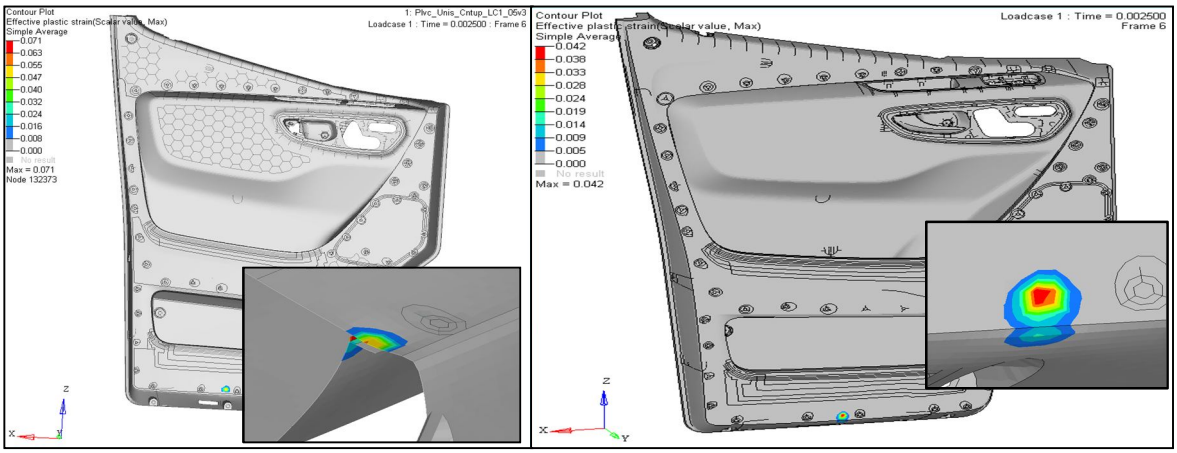


Fig.5.7 Maximum strain limit

Table 2. Load applied on Door pocket area

Load (N)	Stress (N/mm2)	Displacement (mm)
8	42	5
10	53	6.3
12	63	16.3

F. Energy absorb by the door pocket area by applying load 10 N

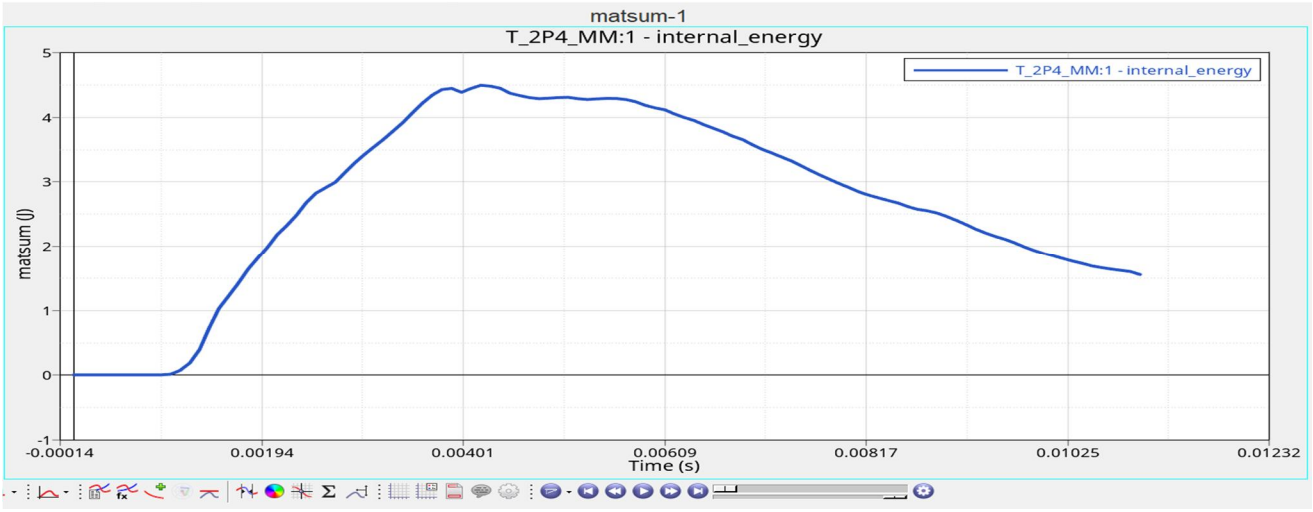


Fig.5.8 Internal energy of door pocket area

V. RESULTS AND DISCUSSION

Impact Analysis shows that the stress and displacement of car door pocket area. The stress and displacement shows the location where is the maximum impact happen. In Theoretical method difficult to get result of complex structure that's why prefers the Finite element method. The car door is analyzed by Ls-dyna Software. Car door Impact test applying the 10N load and velocity is 4429.44 mm/sec. checking the result how much energy absorb by the door.

The max displacement is 6.3 mm in upper pocket area of car door. This analysis reduces the impact by 10%. The maximum stress is 0.053 GPa and Max Pl. Strain is 10.3% in door upper pocket area. The max displacement is 6.02 mm in lower pocket area of car door. The max stress is 0.048 GPa in lower pocket area of car door and the max Pl. strain is 7.1% in door lower pocket area. The displacement is maximum in upper pocket area as compared to lower pocket area. Energy absorbed by the door pocket area is 4.5J.

VI. CONCLUSION

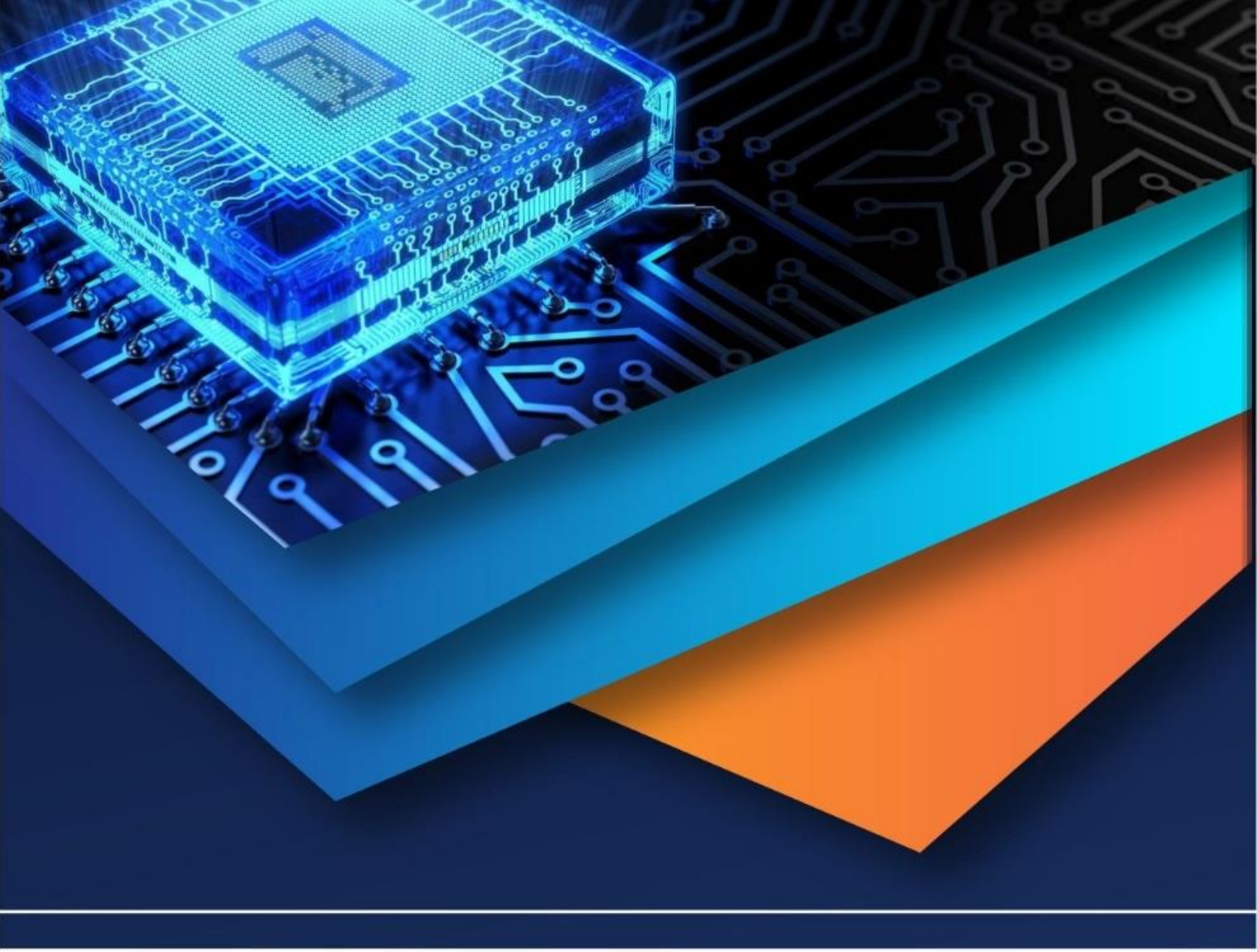
The car door design by catia v5 Software, meshing of car door did in hypermesh software and analysis done by using Ls-Dyna Software. This analysis is done by using the plastic, steel and aluminum material. The Impact analysis of car door is tested by 10N load of Impactor and velocity is 4429.44 mm/sec. The result state that PPTD20 is the better material for the energy absorbing capacity of the door, as per results energy absorbed by the door pocket area is 4.5J. Maximum displacement shows 6.3 mm and maximum plastic strain is 10.3%.

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