International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017),e-ISSN:2455-2585
International Conference on
Recent Explorations in Science, Engineering And Technology (ICRESET'19)
Volume-5, Special Issue-March, 2019.

DESIGN AND IMPACT ANALYSIS OF REDUCTION OF WEIGHT IN CAR DOOR

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Abstract: ***Car door is one of the main parts which are used as protection for passengers from slide collisions. Doors are typically hinged but sometimes attached by other mechanisms such as tracks, in front of an opening which is used for entering and exiting a vehicle. Side impact collision of vehicle is one of the awfully hazardous crashes causing injuries and death annually around the word. In this PROJECT, the most important parameters including material, geometry and rib arrangement were studied to improve the crashworthiness during vehicle-to-vehicle side collision. In the side impact, the side door impact structure is responsible to absorb the most possible kinetic energy. Presently steel is used for car doors construction. We designed side impact beam of different cross sections. The design of car door is designed using CATIA. The aim of the project is to analyze the car door with presently used material steel and replacing with composite materials like aluminum, carbon epoxy, s-glass epoxy, e-glass epoxy. Impact analysis is conducted on door with transient structural analysis using ANSYS software by varying the materials.***

Keywords - car door, Finite element Analysis, Structure, side impact beam, transient structural analysis.

I. Introduction

Doors are one of the major components in a car which provide easy access for passengers into the car. With the growing demand on car styling, comfort, safety and other systems integration (window regulator, latch, speaker, motor and electronics) in the door, designing this system is a great challenge to engineers. Door system mainly consists of window glass, window regulator assembly, door latch, sealing and structural components of the door assembly. Traditionally these parts were designed, manufactured and procured separately. A door module is an assembly of functional elements mounted onto a carrier plate. Unlike conventional door systems, where the window regulator assembly was directly attached to the door inner panel, the door module comprises of a carrier plate with window regulator assembly, glass motor and speaker. The window regulator consists of a motor assembly, one or two rails to guide the glass motion, cursor or glass clamps to support the glass, and mechanisms to move the glass up and down. The window regulator, speaker, and other wire harnesses are mounted on the carrier plate using bolts, rivets, and clips. Nowadays more research are going to design vehicle which uses fuel economically, by light weight engineering using low density material and with advance manufacturing and joining technology and thereby reducing the weight of vehicle. The growing demand for more fuel-efficient vehicle to reduce energy consumption and air pollution provides a challenge for the automotive industry. Door system mainly consists of window glass, window regulator assembly, door latch, sealing and structural components of the door assembly. Traditionally these parts were designed, manufactured and procured separately.

1.1. Car door

Car Doors are typically hinged but sometimes attached by other mechanisms such as tracks, in front of an opening which is used for entering and exiting a vehicle. The window regulator consists of a motor assembly, one or two rails to guide the glass motion, cursor or glass clamps to support the glass, and mechanisms to move the glass up and down.[1] The window regulator, speaker, and other wire harnesses are mounted on the carrier plate using bolts, rivets, and clips. On the other hand, the vehicle door's interior side is typically made up of a variety of materials, sometimes vinyl and leather, other time's cloth and fabric. [2]

(Fig-1: car door)

Design of car door and beam

1.2. Design Parameters

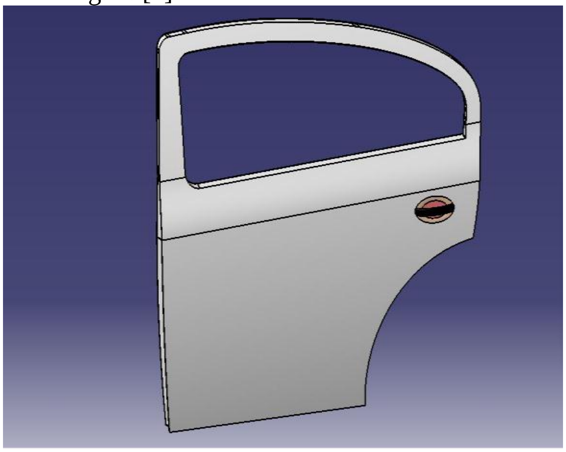
The design parameters were selected from reference papers and OEM's. Some modifications are carried out by varying the thickness and geometrical dimensions. All these dimensions are made with respect to the car door and beam. The existing side impact beam is modified by introducing different cross sections and also evaluating the model using three materials namely Aluminum Alloy, E-Glass Epoxy, S-Glass Epoxy thus reducing the material usage and also the weight of the car door. [3]

Table-1 Specification of materials

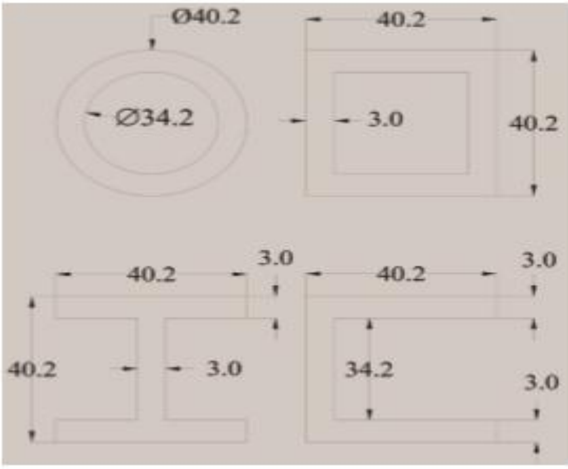
Property	Aluminum alloy	e-glass epoxy	s-glass epoxy
Modulus of Elasticity (GPa)	71	80	89
Poisson's Ratio	0.33	0.3	0.3
Tensile Yield Strength(MPa)	280	nil	nil
Tensile Ultimate Strength(MPa)	310	nil	nil
Mass Density(g/cm^3)	2.77	2.55	2.49

1.3. Design of car door using CATIA

The geometric model of the car door (circular section beam) is done using CATIA Software. The Three Dimensional model of the car door frame is shown in Fig. 2. [4]



(Fig-2: CATIA Model of car door)



(Fig-3 Cross Sections Used)

Table-3 Force acting on the car door

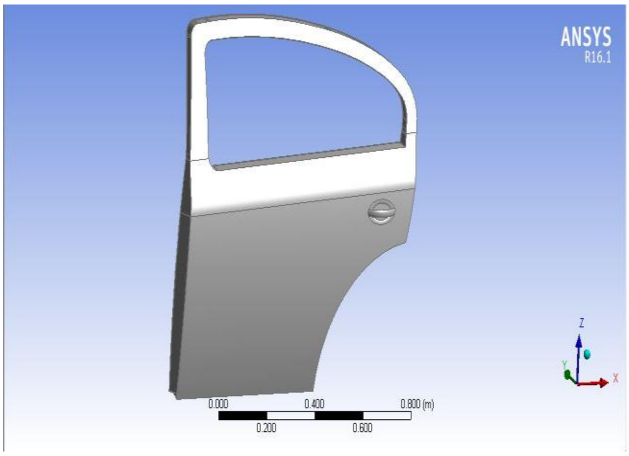
S. No	Location	Load (Kg)	Load (N)
1	Door top	303	3000
2	Centre	810	8000
3	Door bottom	1110	11000

II.Analysis of car door

After the creation of the model using the design software, the geometric model is converted into STEP format in order to avoid data losses occurring due to importation of the geometric design file. There are three main steps involved in the analysis software, namely: pre-processing, solution and post processing. In the pre-processing stage, the geometric domain of the model is imported along with its material properties and boundary constraints. Further the geometric is meshed in several nodes and elements for accurate evaluation of the problem. [5]
In the solution phase, the governing algebraic equations are formed and the unknown values are evaluated. The computed results are again utilized by back substitution method to determine the other additional variables and required information. In the post processing phase, the analyzed results are evaluated and displayed.

1.4. Finite Element Analysis of car door using ANSYS Workbench

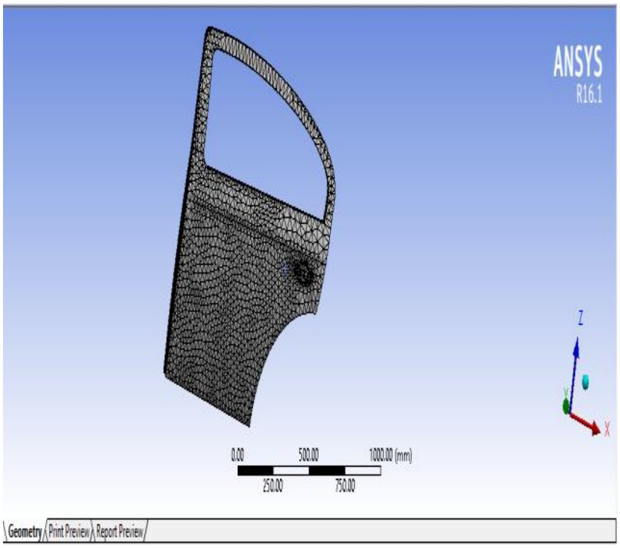
The model of the chassis is saved in STEP format which is imported into ANSYS Workbench. The imported model is shown in Fig-4. [6]



(Fig-4: Imported model in ANSYS Workbench)

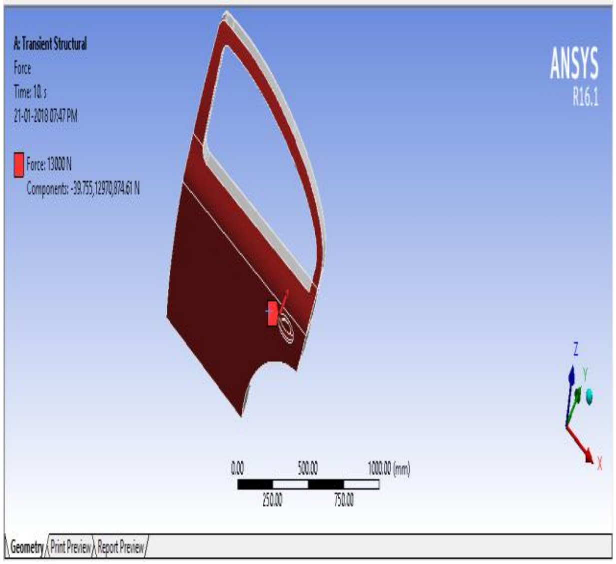
1.5. Meshing and Boundary Conditions

The model of the car door is meshing by the suitable geometry material such as al-alloy, s-glass, and e-glass. Material.

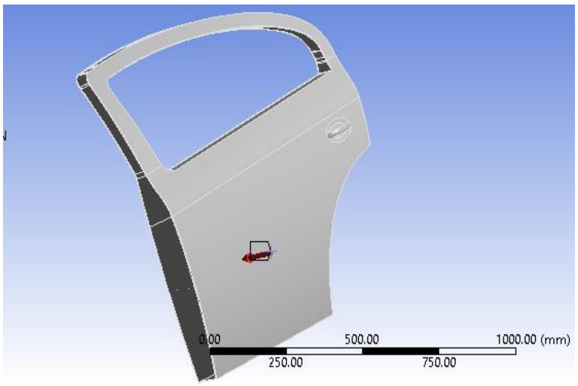


(Fig-5: Meshed model of Car door)

The car door is provided with necessary working loading which is considered to be uniformly distributed throughout the car door. The maximum impact load acting on the door is considered to be 8000 N and the passengers inside the car are weighted to 50kg at the impact in 3s. The finite element model of the car door provided with necessary boundary constraints are shown in the Fig 6 and 7 respectively. [7]



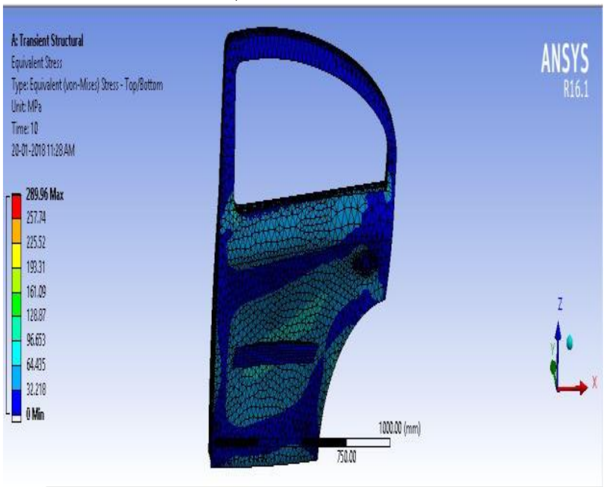
(Fig-6: load acting on outer body)



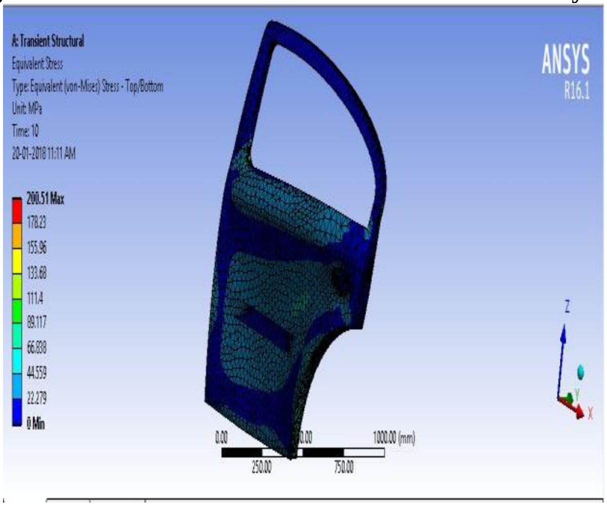
(Fig-7: Load Conditions)

1.6. Static Structural Analysis of car door

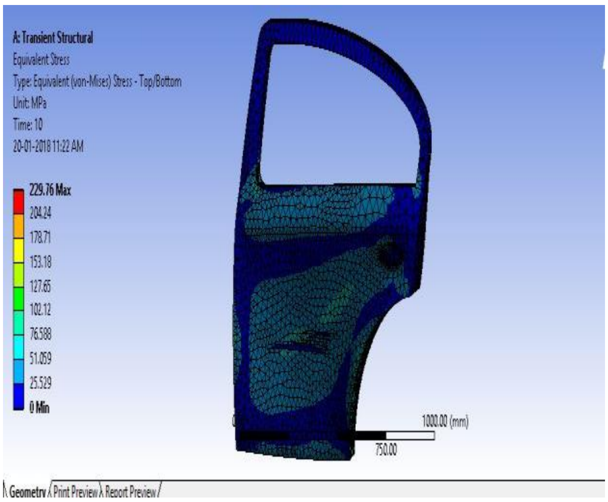
The Finite element static structural analysis of bus chassis model is experimented using three different materials – structural Steel, in the beam with three different materials with four different cross section mentioned above in the figure. The three different materials are aluminum alloy, epoxy-s glass UD, epoxy-e glass UD. The contour plots of all the three materials comprising the Von Mises stress distribution, Deformation and Normal Stress are shown in Fig-8 to Fig 16. [8]



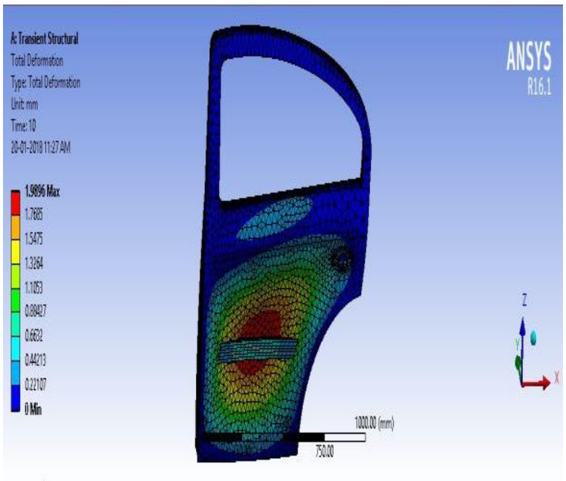
(Fig-8 Von Mises Stress Distribution of aluminum alloy -box)



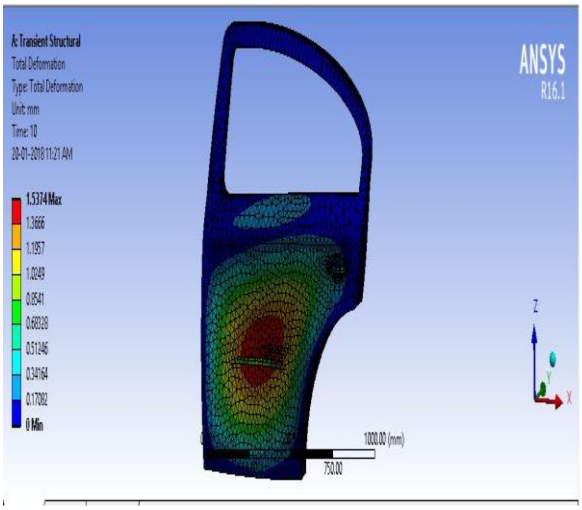
(Fig-9 Von Mises Stress Distribution of S-Glass)



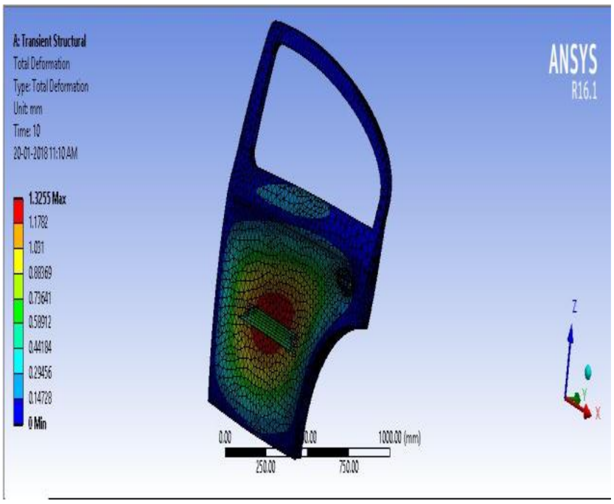
(Fig-10 Von Mises Stress Distribution of E-Glass)



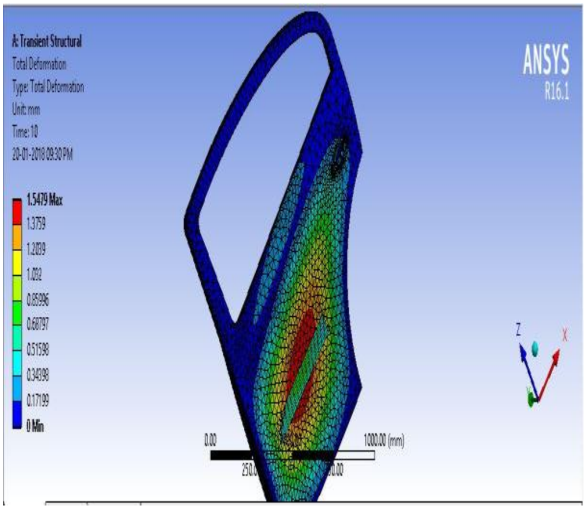
(Fig-11 Total Deformation on Aluminum Alloy-Box)



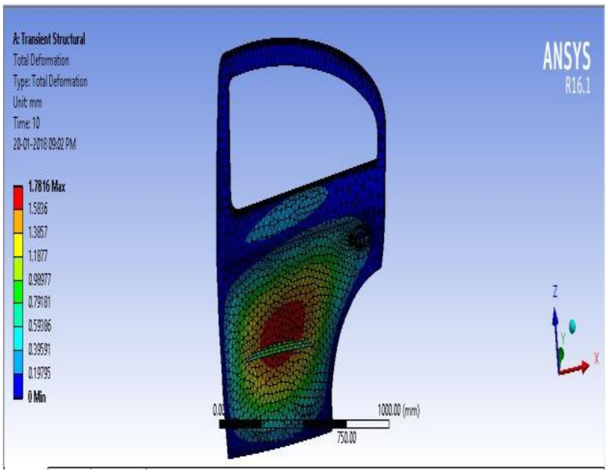
(Fig-12 Total Deformation of e-glass -box)



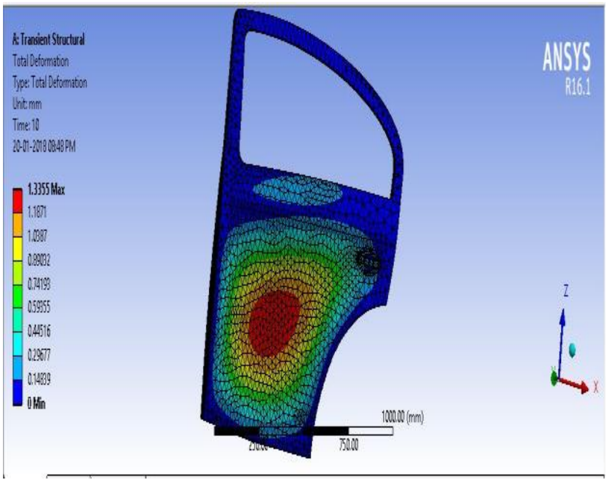
(Fig-13 Total Deformation on S-Glass-Box)



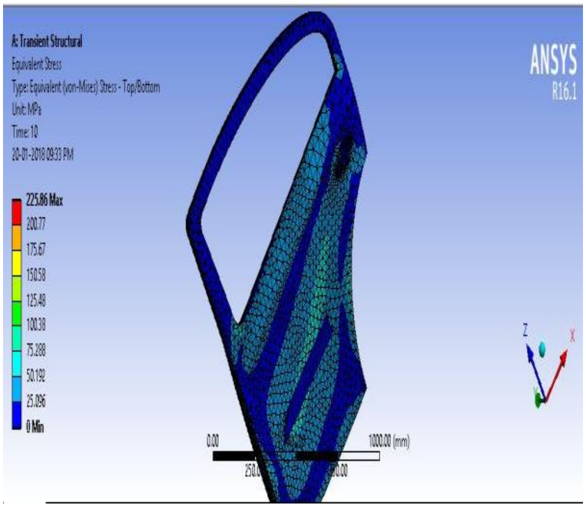
(Fig-14 Total Deformation on Aluminum Alloy - C)



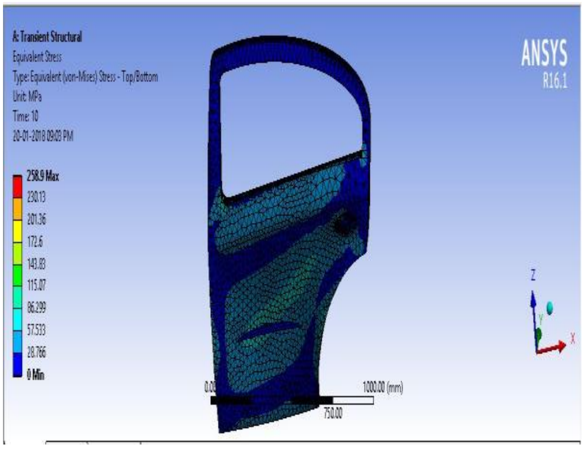
(Fig-15 Total Deformation of e-glass - c)



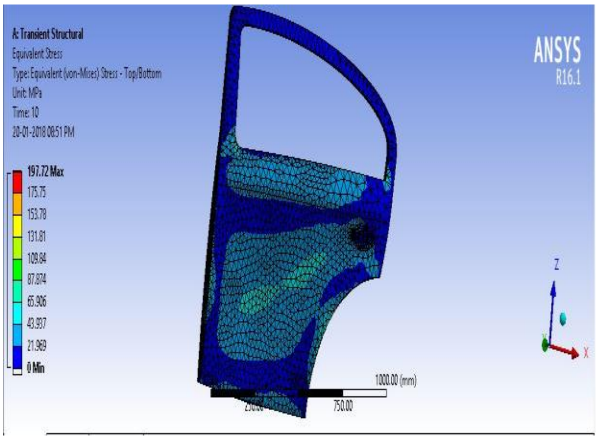
(Fig-16 total deformation of s-glass-c)



(Fig-17 Von Mises Stress Distribution on Aluminum Alloy-C)



(Fig-18 Von Mises Stress Distribution on E-Glass Epoxy-C)



(Fig-19 Von Mises Stress Distribution on S-Glass Epoxy-C)

2. **Optimisation process**

Although the former seems very effective, it is very expensive so that it may only be used for an expensive automobile. Therefore, the automobile industry is trying to use steel, which is not costly and recyclable. Lightweight steel can be achieved by improving the performance of the structure or adopting new manufacturing techniques. One of the efforts is the ULSAB (ultra light steel auto body) concept. ULSAB suggests three main weight reduction techniques such as hydro-forming and the tailor welded blank (TWB). In this research, the TWB technique is utilized for lightweight door design, and a design process is proposed for optimizing the automobile TWB door. In the automotive door assembly, door inner panel is divided into different thickness without reinforcement components and different thickness sheets, plates are assembled by laser welding. The use of tailored steel solutions eliminates the need for additional reinforcements and overlapping joints in the body, saving material and further reducing total weight. In this way, tailored blanks are a significant enabler to meet specified CO2 targets. Reducing the weight of a car reduces CO2 emissions. Objective of this paper is Low cost door design for developing countries India, Srilanka, South Africa without compromising any performance and regulatory requirements for example removing molded trim with hard pad, cost saving approximately 1400 Rs/set. Reducing the weight of door assembly by reducing number of components and by using advance technologies like tailor welded blank and high strength material. Existing design has a water leakage problem from the assembly of inner door panel and seal because of different thickness of inner panel. The parts which are newly designed or modified are designed on the basis of space constrained. The main constrained is that avoids as much as modification in the machined parts. [9]

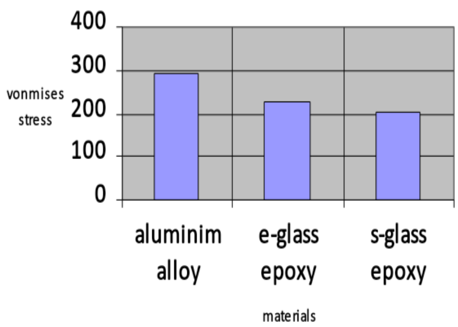
III. Results

Since the problem given is a complex structure, the theoretical method cannot be used to determine accurate values and hence FEA results are taken into consideration. By using ANSYS, the results are tabulated in the Table-4.

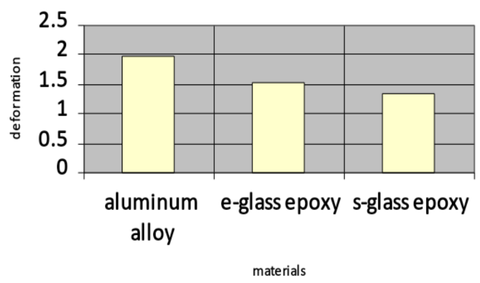
Table-4 Results

Material	Aluminum alloy	e-glass epoxy	s-glass epoxy
Von Mises Stress (MPa)in box	289.96	229.76	200.51
Deformation(mm)in box	1.9896	1.5374	1.3255
Deformation in c section	1.5479	1.7816	1.3355

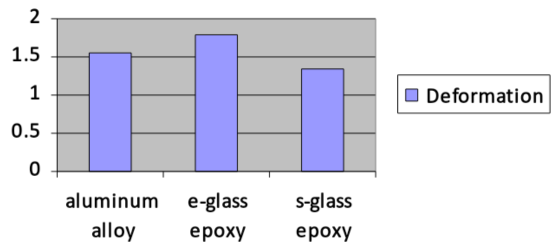
The graphical representation of the data evaluated using ANSYS software is shown in the Fig- 17 and Fig 18. The Fig-17 displays the comparison between the Von Mises Stress Developed in each material while the Fig. 18 displays the comparison of the deflection attained by the three different materials due to application of the loads.



(**Fig-20 Bar Chart of Von Mises Stress observed in MPa box section**)



(Fig-21 Bar Chart of Deformation observed in mm box section)



(Fig-22 bar Chart of Deformation In mm-C sec)

IV. Conclusion

This paper focuses on improving the crashworthiness of the car door by analyzing two different cross sections with three different materials such as ALUMINUM ALLOY, EPOXY-E GLASS UD, and EPOXY-S GLASS UD. By comparison with three materials improved crashworthiness is suitable for S-GLASS EPOXY UD when compared with another two materials. By applying these three materials in practical appliances ALUMINUM ALLOY consuming weight more than the S-GLASS EPOXY, and it also preferable for improved crashworthiness than the e-glass epoxy material.

Acknowledgements

We take the opportunity to express our heartiest gratitude to our Prof. Dr. P. Jayaraman, HOD Department of Mechanical Engineering who gave us this opportunity to execute this project. We convey our gratitude to our Project Guide Mr. D. Prem Kumar, Assistant Professor Department of Mechanical Engineering, who guided us to complete this project by devoting his precious time and shared his knowledge and also helped us to complete the project report. We would also like to thank all the other staffs for their moral support.

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