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International Journal Of Modern Engineering Research (IJMER)

Design and Impact Analysis of a Car Door

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Abstract: *Car door is one of the main parts which are used as protection for passengers from side collisions. Presently steel is used for car doors construction. 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 for different speeds by varying the materials. Best of the result we will consider for the door design. Also we are going to reduce weight of the door by using composite materials replacing with steel. By this we have to reduce the damage percentage of the car and passenger protection. In this project, the Car door is modeled using parametric modeling software Pro/Engineer. Pro/ENGINEER is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design. We have to variety the materials of the car door and speed to impacting of door.*

Keywords: *We are doing impact analysis in the software COSMOS (SOLID WORKS)***.**

I. Introduction

The A vehicle door is a type of door, 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. A vehicle door can be opened to provide access to the opening, or closed to secure it. These doors can be opened manually, or powered electronically. Powered doors are usually found on minivans, high-end cars, or modified cars. Unlike other types of doors, the exterior side of the vehicle door contrasts sharply from its interior side (the interior side is also known as the car door panel): The exterior side of the door is designed of steel like the rest of the vehicle's exterior. In addition, its decorative appearance, typically colored with a design, is intended to match with the rest of the vehicle's exterior, the central purpose being to add to the overall aesthetic appeal of the vehicle exterior.

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. Because the car door panel is typically intended to match the rest of the styles used in the car's interior, the choice of cover materials depends on the rest of the styles used in the vehicle's inner body like the dashboard, carpet, seats, etc. However, unlike the material used on the exterior side of the vehicle door, the material on the interior side serves a greater purpose other than just aesthetic appeal. While the materials that makes up the interior side are intended to match their surroundings and contribute to the overall aesthetic appeal, there's an additional purpose of coziness and comfort. This is to say, a car door panel has interior parts that contribute to the overall functionality and ergonomics of the ride, such as: armrests; various switches; lights; electronic systems like the window controls and locking mechanism; etc.

II. Literature Review

Previous studies by different researches show that the efficient design and increase use of composite materials into the automotive parts directly influences the car safety, weight reduction and gas emission, because the efficient design can absorb more deformation and composite materials have high specific strength (strength to density) and high specific stiffness (stiffness/density). They also have very high impact load absorbing and damping properties.

The side impact door should have the ability to absorb as much deformational energy as possible without breaking. Steel is still the most widely used material for beam members, but the steel increases the total weight of the car. However, breakthroughs in the application of lighter materials, such as composite, are being initiated in the automotive industry. Correct fiber orientation and stacking sequence of the cross-ply laminate contribute to higher energy absorption when compared to steel equivalent.

The composite materials have high specific energy absorption when compared to steel. The properties like high specific strength and high specific stiffness are attractive for the construction of lightweight and fuel efficient vehicle structures. The energy absorption capability of the composite materials offers a unique combination of reduced weight and improves crashworthiness of the vehicle structures. Fuel efficiency of the vehicle directly depends on the weight of the vehicle. The carbon fiber composite body structure is 57% lighter than steel structure of the same size and providing the superior crash protection, improved stiffness and favorable thermal and acoustic properties. The composite materials are replacing most of the steel structures. Rotors manufactured using RTM (Resin Transfer Molding) for air compressor or super chargers of cars are used to substitute for metal rotors which are hard to manufacture. The composite material was for the first time introduced to the formula-1 in 1980 by McLaren team. Since then the crashworthiness of the racing cars has improved beyond all recognition. They used the carbon fiber composite to manufacture the body, which is low weight, high rigidity and provided the high crash safety standards. The lightweight composite materials are already finding the exciting break in the automotive field as a means to increase the fuel efficiency. The vehicle weight directly contributes about 75 percent of fuel consumption. The vehicle industry can anticipate an aggressive 6 to 8 percent reduction in fuel consumption with 10 percent decrease in vehicle weight. This reduces around 20 kilogram of carbon dioxide emission per kilogram reduction in weight over the vehicle's lifetime. The report from the united states and Canada predicted that plastics and composites would be widely used applied to body panels, bumper systems, flexible components, trims, drive shaft and transport parts of cars. Also rotors manufactured using RTM (Resin Transfer Moldings) for air compressor or superchargers of cars have been used to substitute for metal rotors which are difficult to machine. Composites have been used to substitute flexi spline materials in harmonic drives.

III. Modeling Of Car Door

The specification of DOOR for CAR below

The software used for Modelling of car door is Pro-E and software it is developed by **Parametric Technology Corporation**

This is CAD/CAM/CAE software but we are using this for only 3-D part modelling (CAD).

This CAD includes.

1. Sketcher
2. Part modelling (part design)
3. Surface Design
4. Assembly Design
5. Drafting

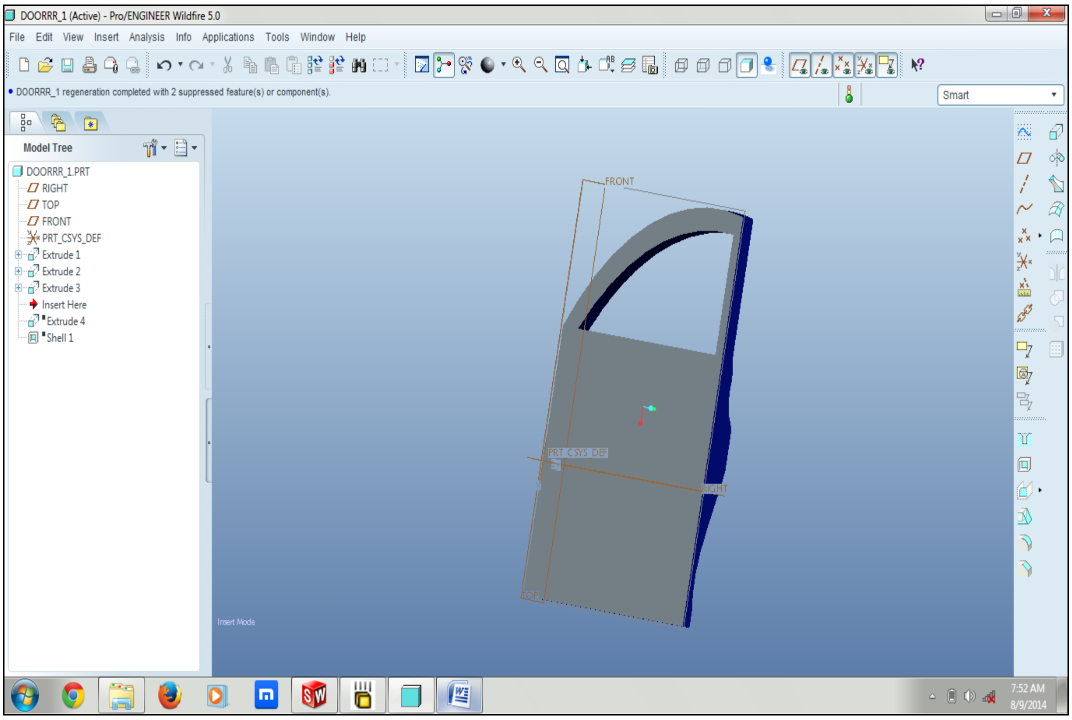
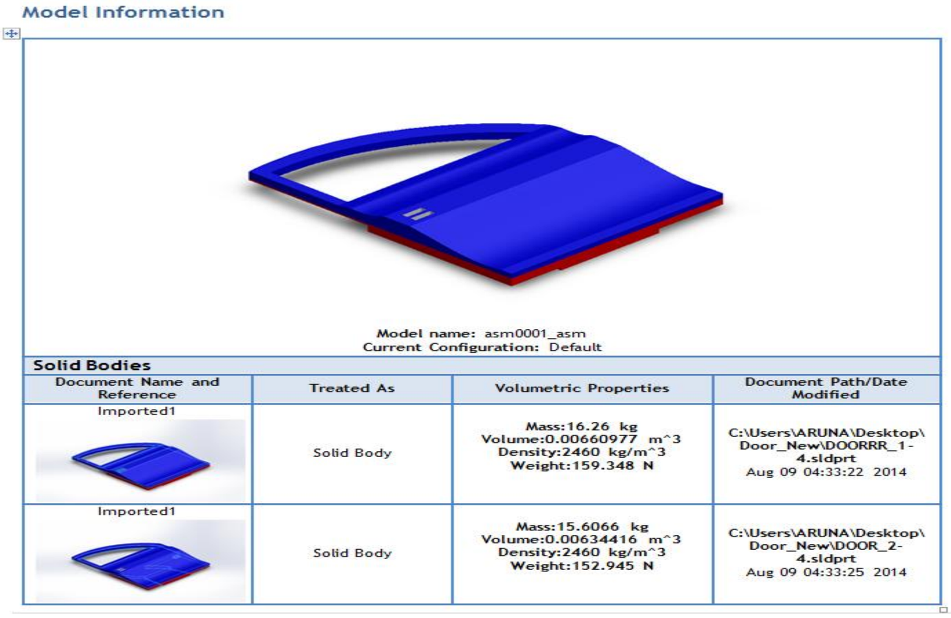


Figure 1: 3-D model of Car Door using Solid works-Design 1-Original



Model Information

Model name: asm0001_asm
Current Configuration: Default

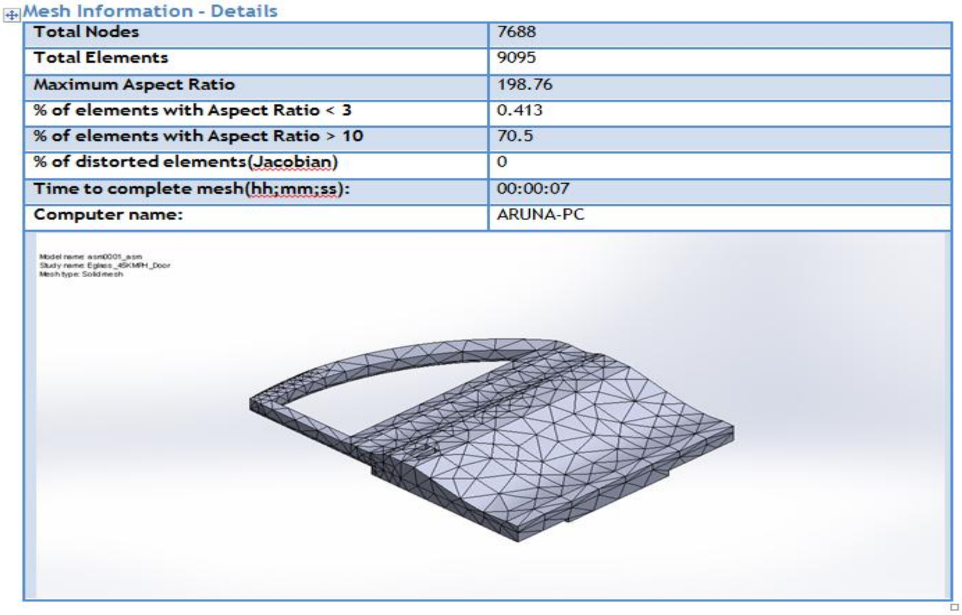
Solid Bodies

Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Imported1	Solid Body	Mass:16.26 kg Volume:0.00660977 m^3 Density:2460 kg/m^3 Weight:159.348 N	C:\Users\ARUNA\Desktop\Door_New\DOORRR_1-4.sldprt Aug 09 04:33:22 2014
Imported1	Solid Body	Mass:15.6066 kg Volume:0.00634416 m^3 Density:2460 kg/m^3 Weight:152.945 N	C:\Users\ARUNA\Desktop\Door_New\DOOR_2-4.sldprt Aug 09 04:33:25 2014

Figure 2: 3-D model information of Car Door with mass 16.26Kg

IV. Meshing Of Car Door

The Figure.3 shows the meshed model of door. The Discretization (Mesh generation) is the first step of Finite Element Method. In this step the component or part is divided into number of small parts. In discretization the no of elements are 9095, and 7688 nodes. The effect of force on each portion of the component is not same. The purpose of discretization is to perform the analysis on each small division separately



Mesh Information - Details

Total Nodes	7688
Total Elements	9095
Maximum Aspect Ratio	198.76
% of elements with Aspect Ratio < 3	0.413
% of elements with Aspect Ratio > 10	70.5
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:07
Computer name:	ARUNA-PC

Figure 3: 3-D Meshing model information of Car Door

The Figure.4,5,6: shows the study model of door. After the application of boundary conditions and force, the next step is to perform the structural analysis of door. In this structural analysis, we are mainly concern with the total deformation and the stresses acting on the door (von-masses stresses). When the force is applied, the slight deformation and also the stresses take place in the crankshaft. The total deformation of crankshaft is shown in Figure.4. The deformation in the door is not same throughout. The portion in red color shows that the deformation at that region is maximum and the portion in blue color shows that the deformation is minimum in that region.

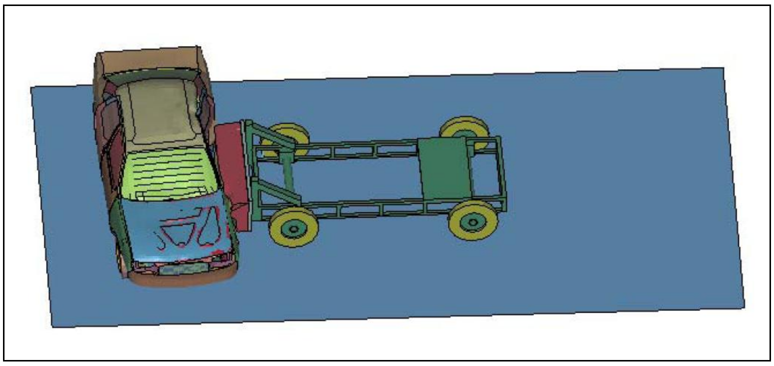
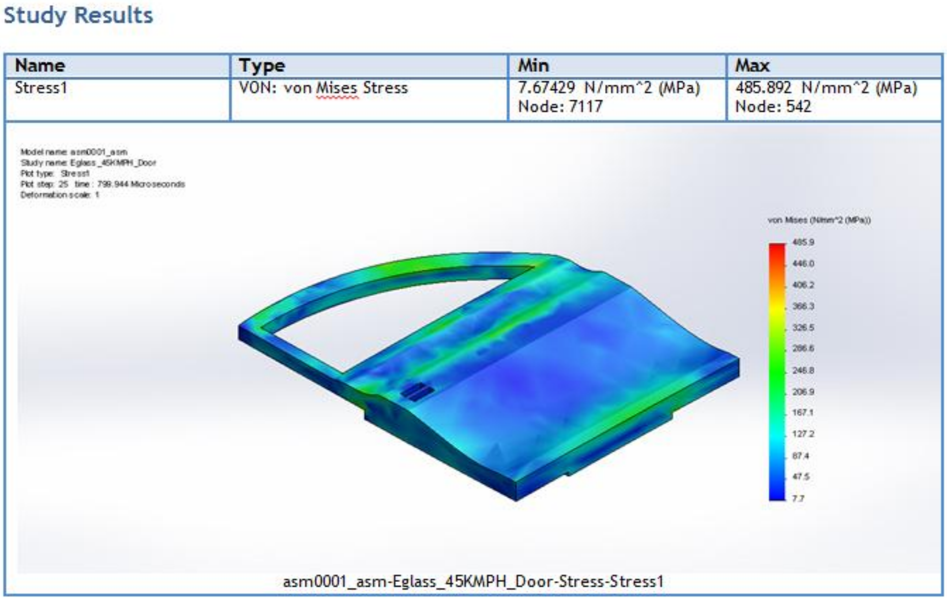


Figure 4: 3-D model stress study of Car Door

V. Study Stress Of Car Door

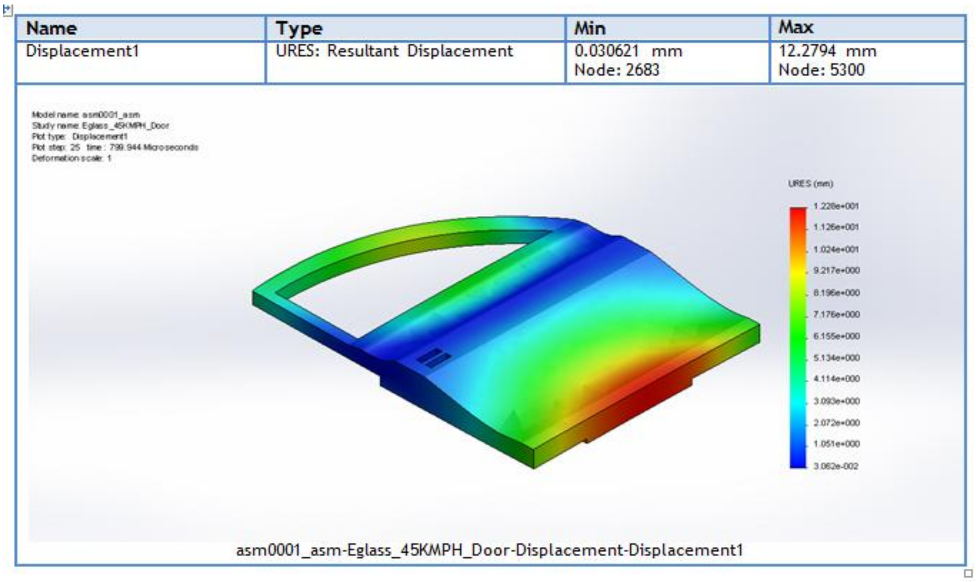


Study Results

Name	Type	Min	Max
Stress1	VON: von Mises Stress	7.67429 N/mm^2 (MPa) Node: 7117	485.892 N/mm^2 (MPa) Node: 542

Figure 5: 3-D model stress study of Car Door Min 7.674 & Max 485.49(Mpa)

VI. Displacement Stress Of Car Door



Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.030621 mm Node: 2683	12.2794 mm Node: 5300

Figure 6: 3-D model Displacement study of Car Door Min 0.030 & 12.27(Mpa)

VII. Displacement Stress Of Car Door

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	6.30705e-005 Element: 2372	0.00415769 Element: 1985

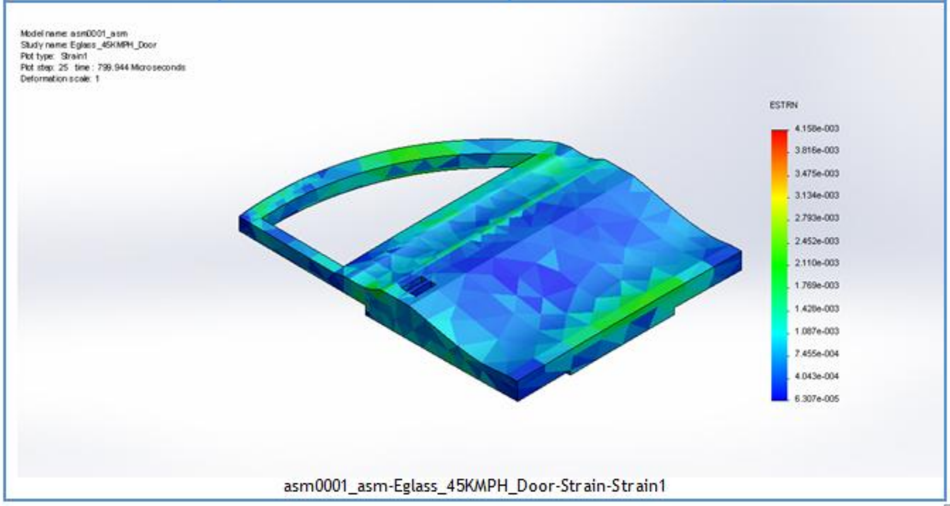


Figure 7: 3-D model strain study of Car Door Min 6.307 & Max 0.0041(Mpa)

The stress acting on the Design1Original door is shown in Figure.5, 6, and 7.

VIII. FIGURES AND TABLES

After applying loading and boundary conditions results from Solid works were obtained and compiled in table

Eglass Epoxy:

Speed	**Stress**		**Displacement**		**Strain**	
Material (Eglass Epoxy)	**Stress Min(σ)MPa**	**Stress Min (σ)MPa**	**Displacement Min Mm**	**Displacement Minm**	**Strain(min)**	**Strain(max)**
45	**7.66411 N/mm^2**	**486.55 N/mm^2**	**0.0414237 mm**	**12.0775 mm**	**8.54216e-005**	**0.00470882**
60	**10.5646 N/mm^2**	**707.566 N/mm^2**	**0.110908 mm**	**18.0986 mm**	**0.000103121**	**0.00665921**
80	**5.94308 N/mm^2**	**1059.51 N/mm^2**	**0.152936 mm**	**24.6295 mm**	**0.000101913**	**0.00883602**
100	**15.7078 N/mm^2**	**1348.39 N/mm^2**	**0.267476 mm**	**31.2923 mm**	**0.000149278**	**0.0109856**

Table1: Results obtained from SOLID WORKS

Sglass Epoxy:

Speed	**Stress**		**Displacement**		**Strain**	
Material (Sglass Epoxy)	**Stress Min (σ)MPa**	**Stress Min (σ)MPa**	**Displacement Min Mm**	**Displacement Min m**	**Strain(min)**	**Strain(max)**
45	**7.67429 N/mm^2**	**485.892 N/mm^2**	**0.030621mm**	**12.2794 mm**	**6.30705e-005**	**0.00415769**
60	**11.5391N/ mm^2**	**610.998 N/mm^2**	**0.0398429mm**	**18.3876 mm**	**5.34882e-005**	**0.00484095**
80	**11.2458 N/mm^2**	**886.518N /mm^2**	**0.152936mm**	**24.6295 mm**	**0.000101913**	**0.00883602**
100	**10.1045 N/mm^2**	**1114.93N /mm^2**	**0.11594mm**	**30.9996 mm**	**7.59825e-005**	**0.00992091**

Table1: Results obtained from SOLID WORKS

Steel Epoxy:

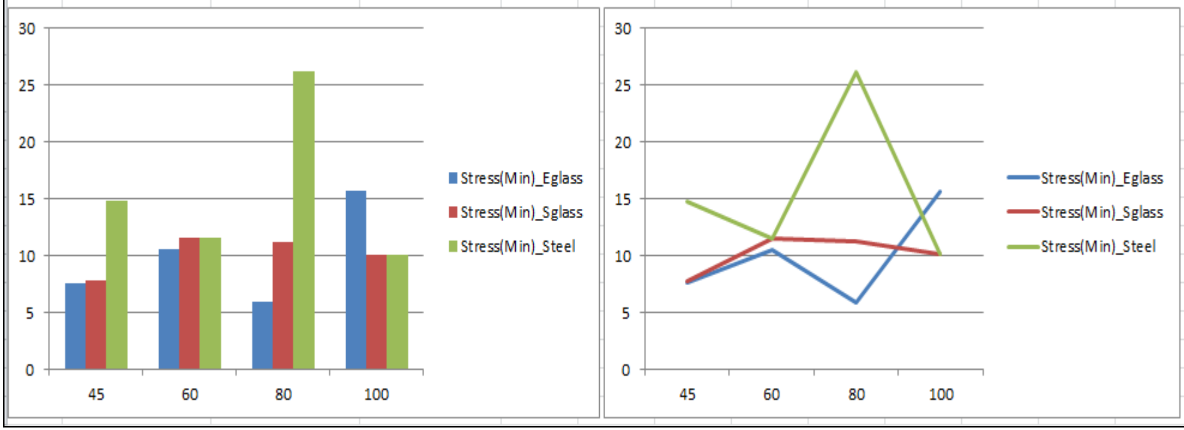
Speed	Stress		Displacement		Strain	
Material (Steel)	Stress Min (σ)MPa	Stress Min (σ)MPa	Displacemen t Min Mm	Displacement Min m	Strain(min)	Strain(max)
45	14.8305N/ mm^2	1922.55 N/mm^2	0.0185283 mm	11.2098 mm	3.86505e-005	0.0059074
60	11.5391N/ mm^2	610.998 N/mm^2	0.0398429m m	18.3876 mm	5.34882e-005	0.00484095
80	26.2071 N/mm^2	3092.92 N/mm^2	0.0283487 mm	22.4748 mm	4.94524e-005	0.00971505
100	10.1045 N/mm^2	1114.93 N/mm^2	0.11594mm	28.982 mm	7.59825e-005	0.00992091

Table1: Results obtained from SOLID WORKS

GRAPHS:

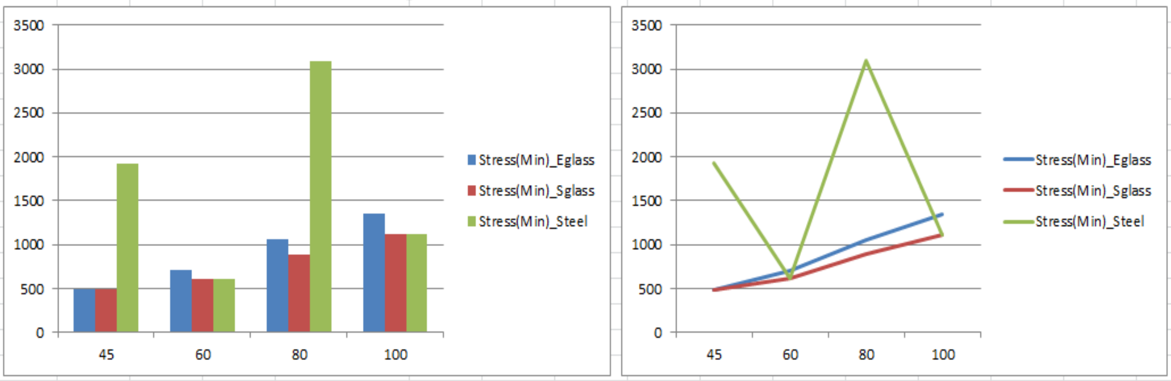
Stress Min (Eglass, Sglass, Steel):

Speed	Stress(Min)_Eglass	Stress(Min)_Sglass	Stress(Min)_Steel
45	7.6	7.8	14.83
60	10.56	11.53	11.53
80	5.94	11.24	26.2
100	15.7	10.1	10.1



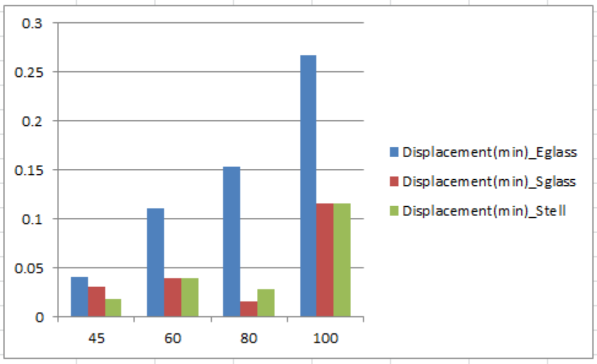
Stress Max (Eglass, Sglass, Steel):

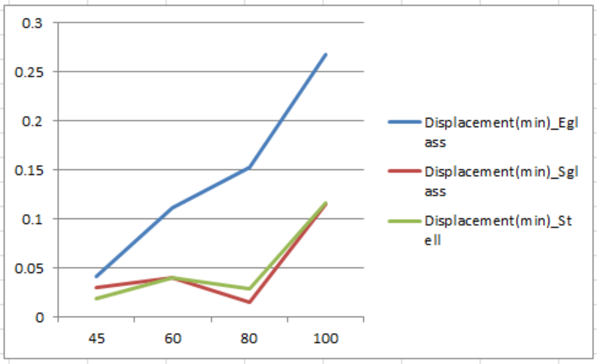
Speed	Stress(Mi	Stress(Mi	Stress(Min)_Steel
45	486.55	485.89	1922.55
60	707.56	610.99	611
80	1059.51	886.51	3092.92
100	1348.31	1114.93	1114.9



Displacement Min(Eglass, Sglass, Steel):

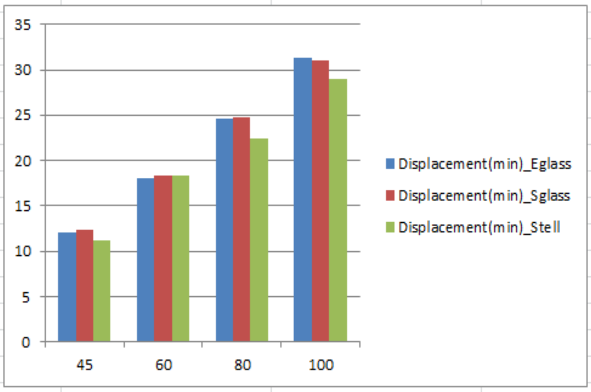
Speed	Displacem	Displacem	Displacement(min)_Stell
45	0.0414	0.0306	0.0183
60	0.1109	0.0398	0.0398
80	0.1529	0.0152	0.0283
100	0.2674	0.1154	0.1159

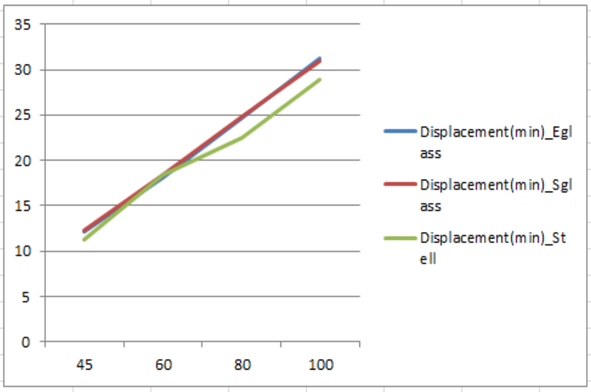




Displacement Max(Eglass, Sglass, Steel):

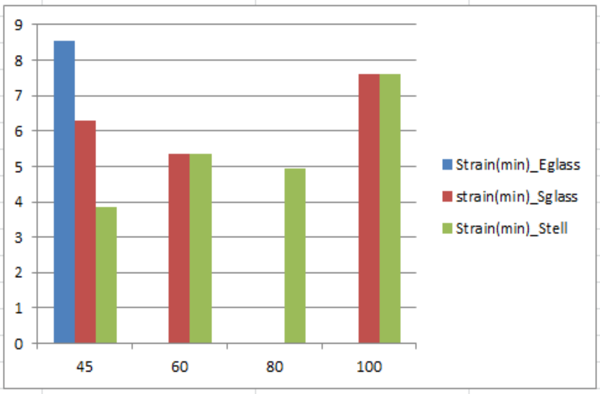
Speed	Displacement(min)_Eglass	Displacement(min)_Sglass	Displacement(min)_Stell
45	12.077	12.279	11.209
60	18.098	18.387	18.387
80	24.629	24.762	22.474
100	31.292	30.999	28.982

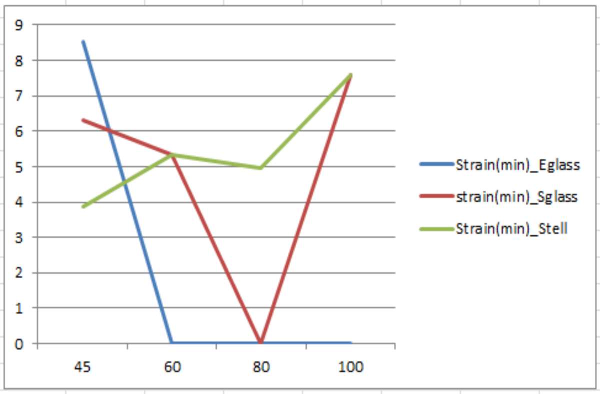




Strain Min(Eglass, Sglass, Steel):

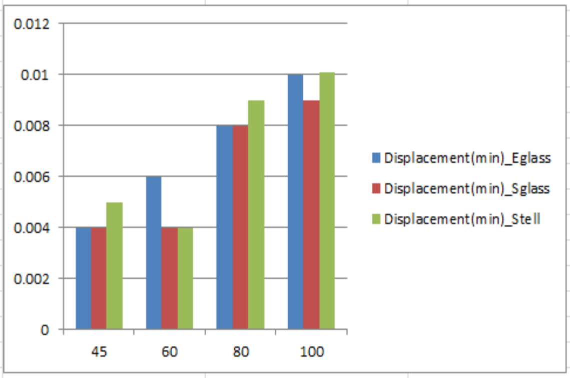
Speed	Strain(min)_Eglass	strain(min)_Sglass	Strain(min)_Stell
45	8.524	6.307	3.865
60	0.0001	5.348	5.348
80	0.0001	0.0001	4.945
100	0.0001	7.598	7.598

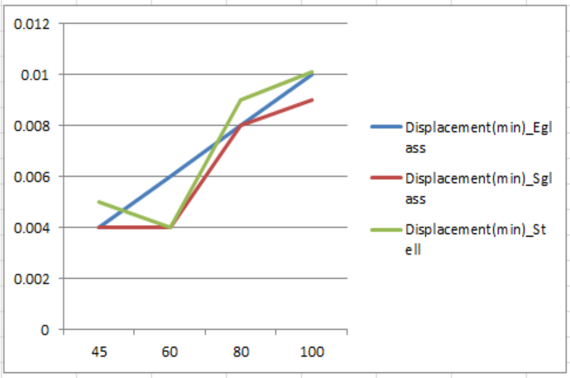




Strain Max(Eglass, Sglass, Steel):

Speed	Displacement(min)_Eglass	Displacement(min)_Sglass	Displacement(min)_Stell
45	0.004	0.004	0.005
60	0.006	0.004	0.004
80	0.008	0.008	0.009
100	0.01	0.009	0.0101





IX. CONCLUSION

Finite Element analysis of the impact of the car door has been done using FEA tool SOLID WORKS. From the results obtained from FE analysis, many discussions have been made.

In this study, Steel, Eglass, Sglass epoxy materials are used for side-door impact, for passenger cars, was designed to reduce weight, as well as to improve impact energy absorption; Structural modifications were tidied using FEA, in order to determine a suitable cross-section for the side-door impact. Furthermore, the impact energy absorption characteristics of Steel, Eglass, Sglass Epoxy were also investigated using impact test.

1. Results show the improvement in the strength of the door as the maximum limits of stresses.
   The value of von-misses stresses that comes out from the solid works is far less than material yield stress so our design is safe.
2. The strength of the car door is also increased (weight Reduction) from change of material from steel to Eglass epoxy and sglass epoxy.
3. As the cost of the car door is increased by using the composite materials for the car door manufacturing and decrease the risk from the collisions.
4. Above Results shows that FEA results conformal matches with the theoretical calculation so we can say that FEA is a good tool to reduce the time consuming theoretical work.

Acknowledgements

The support extended by the guide (Smt. Satya Prakash) and college authorities is highly appreciated and acknowledged with due respect.

REFERENCES

[1] S. Acierno, R. Kaufmanc, F.P. Rivara, D.C. Grossman, and C. Mock, Vehicle mismatch: Injury patterns and severity, Accid. Anal. Prev. 36 (2004), pp. 761–772.

[2] M.D. Buhmann, Radial Basis Functions: Theory and Implementations, Cambridge University Press, New York,2003.

[3] H. Fang, M. Rais-Rohani, Z. Liu, and M.F. Horstemeyer, A comparative study of metamodeling methods for multiobjective crashworthiness optimization, Comput. Struct. 83 (25–26) (2005), pp. 2121–2136.

[4] H. Fang, K. Solanki, and M.F. Horstemeyer, Numerical simulations of multiple vehicle crashes and multidisciplinary crashworthiness optimization, Int. J. Crashworthiness 10 (2) (2005), pp. 161–171.

[5] H. Fang and M.F. Horstemeyer, A generic optimizer interface for programming-free optimization systems, Adv. Engg. Software 37 (6) (2006), pp. 360–369.

[6] H. Fang and M.F. Horstemeyer, Global response approximation with radial basis functions, Engg. Optimiz. 38 (4)(2006), pp. 407–424.