International Journal of Engineering Research and Development
e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 11, Issue 03 (March 2015), PP.21-26

305Vehicle Door Sag Evaluation Using FEA

Sagar Arun Shinde[1], Ravindra R. Navthar[2]
[1]*M.E. Student, Dept. of Mechanical Engineering, P.D.V.V.P College of Engineering Ahmednagar, Savitribai Phule Pune University.*
[2]*Associate Professor, Dept. of Mechanical Engineering, .D.V.V.P College of Engineering Ahmednagar, Savitribai Phule Pune University.*

Abstract:- One of the many factors that lead to first impression on quality aspect of the car is door itself. Vehicle door is the first part that customer handle while buying the car. Thus the quality of the door needs to be updated considering the present and future handling of door. When the car is new the performance of door is almost satisfactory, but in some situations like unusual handling of door by kids, unusual handling during servicing or repairing some extra vertical force may get applied to the door. And that affect door working and results in to door sag.
So it's important to consider the door performance in sag in advance. Thus aim of this paper is to study the existing door hinge performance in sag and to find out the optimized solution and to check the possibilities of weight reduction of hinges.

Keywords:- FEA, Door Sag, BIW, Stiffness

I. INTRODUCTION

One of the many factors that lead to first impression on quality aspect of a car is the door design itself. A vehicle door is a main closure of vehicle which is used for entering and exiting of a vehicle.

Several types of door are used on each vehicle built, although the construction of the various doors is similar regardless of the location of the door on the vehicle. The door is composing of two main panels, an outer and an inner panel, both being of all steel construction. The door derives most of it strength from the inner panel since this is constructed mainly to act as a frame for the door. The door outer panel flanges over the inner panel around all its edge to form a single unit, which is then spot welded or bonded with adhesive to the frame. The inner panel has holes for the attachment of door trim. The trim consists of window regulator assembly and door locking mechanism. These assemblies are installed through the large holes in the middle of the inner panel. The inner panel forms lock pillar and also the hinge pillar section of the door. Small reinforcement plates are used between the outer and inner panel both where the lock is inserted through the door and where the hinges are attached to the door. Handle protrudes, or is recessed to give a more streamlined effect and so to create better aerodynamics.

The upper portion of the door has large opening which is closed by glass. The glass is held rigidly by the window regulator assembly, and when raised it slides in a channel in the opening between the outer and inner panel in the upper portion of the door. When fully closed the closed the window seats tightly in this channel, effectively sealing out the weather. Typically sliding doors and side swing doors are main types of doors used in vehicle. In passenger car side swing doors are generally hinged and mounted on mounted on A-Pillar for front door and on B-pillar for rear door etc.
Typical passenger car door consisting of front panel, inner panel, hinges, glass, trims, mirror and other mechanism i.e. window winding mechanism

A. The Primary Function And Working Of Vehicle Door

Door are used to enter and exit a vehicle, also it creates barrier between passenger and outside environment because of which passenger get saved or gets less impact from outside force.

Its working should be very smooth, comfortable and give absolute pleasure while opening and closing door, also it should rotate smoothly on its axis. Getting pleasing sound while closing door exhibits high quality of engineering. Vehicle door consists of a number of different component and materials.

The actual door consists of a number of different components and materials. Basically the main structure is build up by spot welded panels. The trim and accessories are attached in different ways.

II. PROBLEM DEFINITION

In the vehicle under our study the front door hinges which are used are carryover from existing vehicle. The Aim is to change the design parameter of hinge to optimum value, without affecting the standard requirements of part, so that we can achieve weight reduction and cost reduction. Also we need to carry out the door sag study using FEA for new optimized hinge to check it satisfy the required specification for door sag.

A. Need to Study Door Sagging

A vehicle door is required to be closed easily and smoothly. Self-weight and vertical load on latch point result in door sagging because of this difficulty encountered in unlatching of door while opening and engagement of door latch while closing the door. And it result in to change in orientation of shape of door.

Adverse Effect Due to Door Sagging

1. Misalignment at latch.
2. Affect the sealing performance of door.
3. The unwanted sound appears while opening and closing of door.
4. The Gap and flush between door and surrounding changes.
5. Vibration level at door increases.
6. The aesthetic look of car changes.

III. GEOMERICAL CONFIGURATION

A. CAD Model

CAD modeling of Door parts carried out in CATIA V5

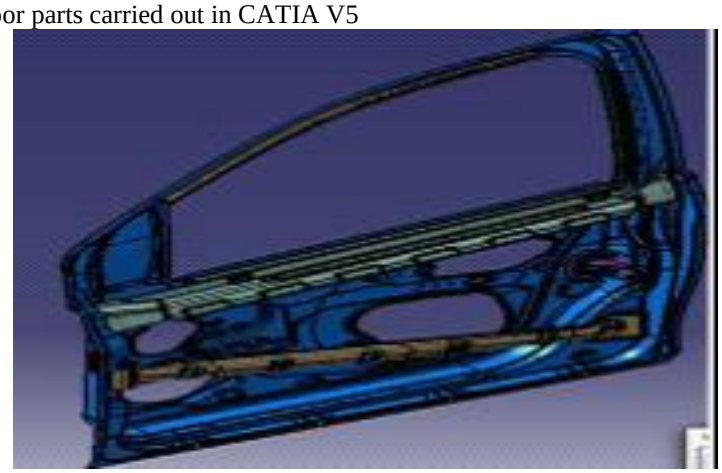

Fig-1 CAD model of Door

IV. FINITE ELEMENT ANALYSIS

A. Meshing Details

Meshing Of Clean Geometry

After making sure that all geometry is ready start the meshing. Following are points need to consider in meshing.

A) We need to carry out the meshing on mid-surface that we have got from clean geometry

B) Select element size as per geometry

C) Create the washer where ever required so have smooth flow of mesh

D) The Mesh density need to check at critical areas

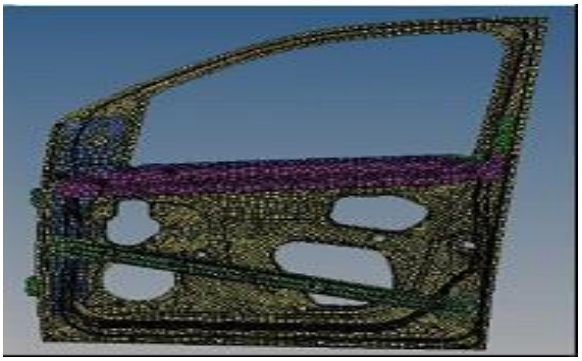

Fig-2 Meshed CAD data

B. Application Of Material Properties, Load and Boundary Condition

A) After completion of meshing apply properties to the parts like thickness, material properties to part.

B) After making sure that we have applied all material properties to all part start the boundary condition application.

C) Apply the Vertical load of 100 kg at latch point

V. INITIAL CONDITION ANALYSIS

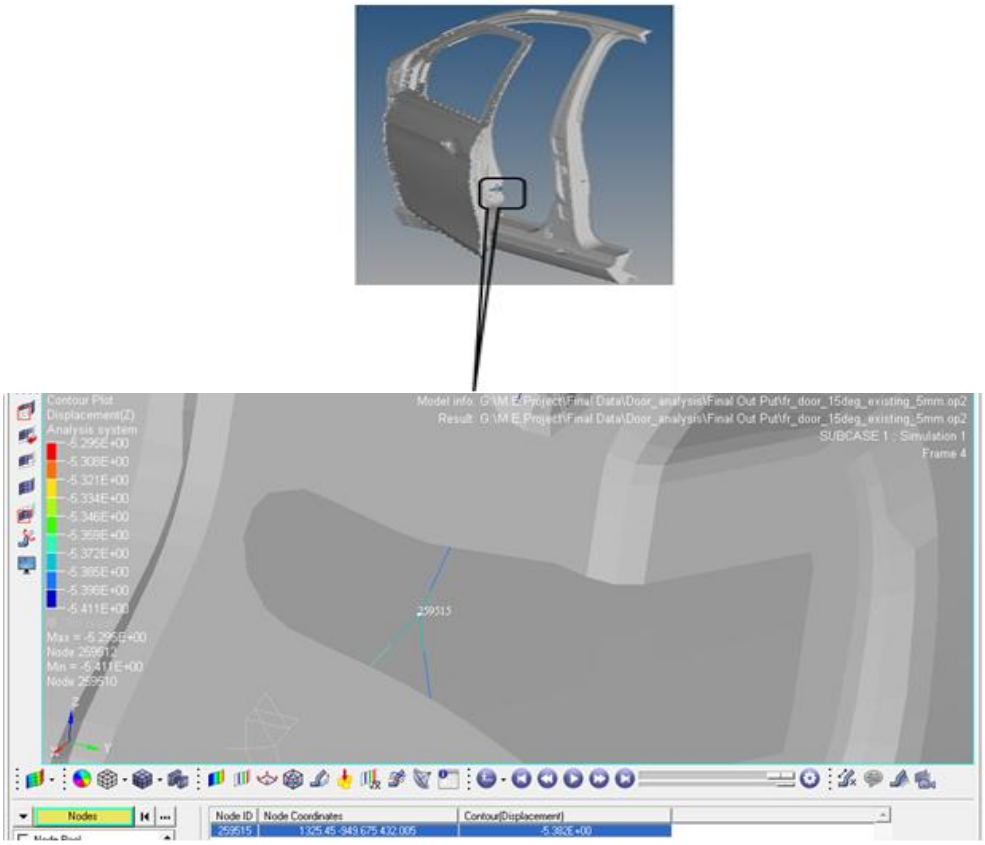

Fig-6 Displacement At Latch Point For Worst Load Condition

From above displacement plot we get the vertical displacement at latch point node (node no. 259515) is 5.38 mm. And per acceptable criteria for vertical displacement at latch point is must be less that 10 mm. The Permanent deformation for the same note we got is 0.39mm and that is less that acceptable criteria which is 1mm We can conclude from above displacement plot that the current used hinges satisfy the specification requirement of door in Sag.

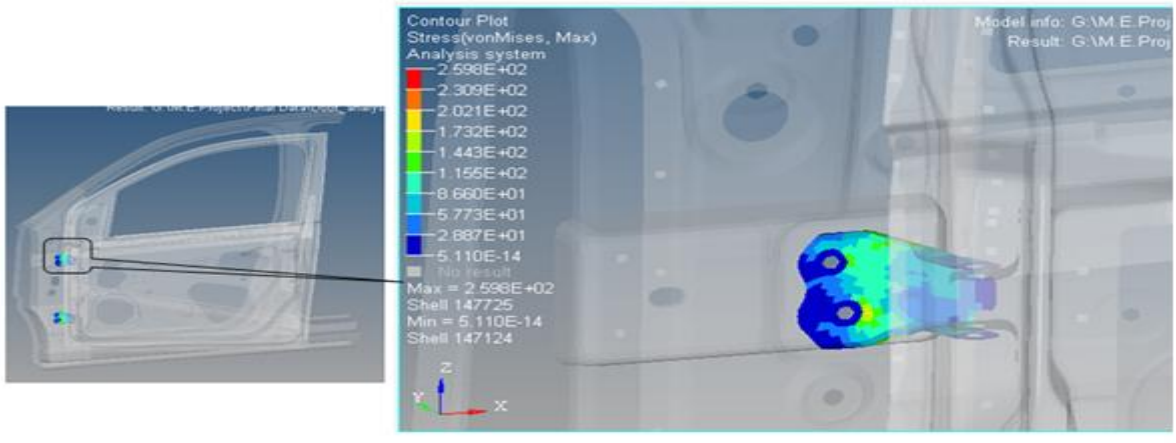

Fig-7 Stress Distribution At Upper Hinge For Worst Load Condition

From above stress plot for upper hinge for worst loading condition we get the maximum induced stress value 259.8N/mm2. And per acceptable criteria for maximum stress for hinge material must be less that 340 N/mm2 We can conclude from above stress plot that the stress induced in current used hinges are much more less that acceptable criteria.

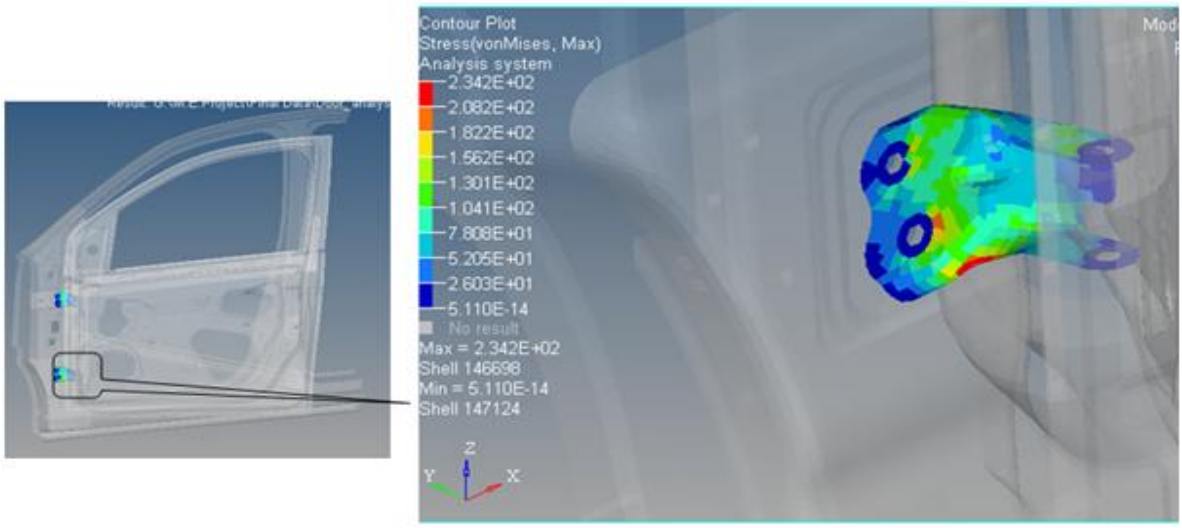

Fig-8 Stress Distribution At Lower Hinge For Worst Load Condition

From above stress plot for lower hinge for worst loading condition we get the maximum induced stress value 234.2N/mm2. And per acceptable criteria for maximum stress for hinge material must be less that 340 N/mm2 We can conclude from above stress plot that the stress induced in current used hinges is much more less than acceptable criteria.

VI. OPTIMIZED CONDITION ANALYSIS

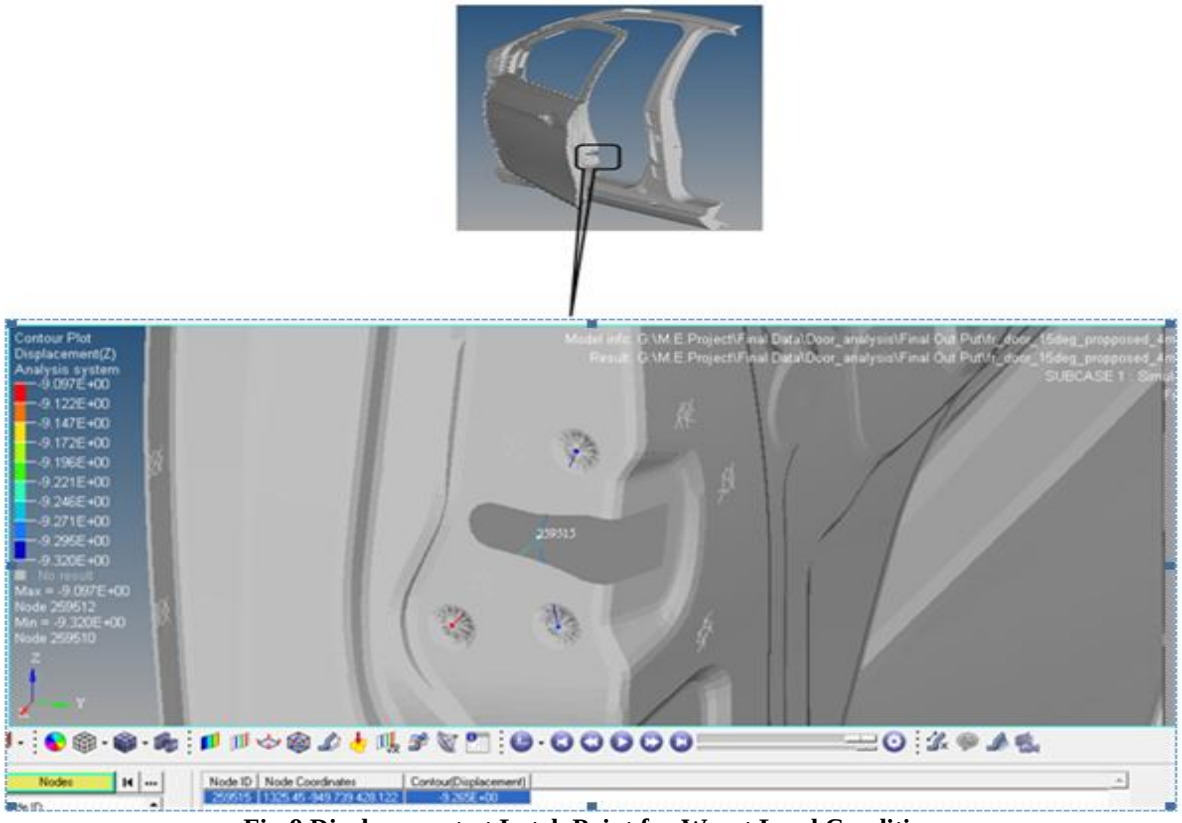

Fig-9 Displacement at Latch Point for Worst Load Condition

From above displacement plot we get the vertical displacement at latch point node (node no. 259515) is 9.0 mm. And per acceptable criteria for vertical displacement at latch point is must be less that 10 mm. The Permanent deformation for the same note we got is 0.7mm and that is less that acceptable criteria which is 1mm We can conclude from above displacement plot that the optimized hinges satisfy the specification requirement of door in Sag.

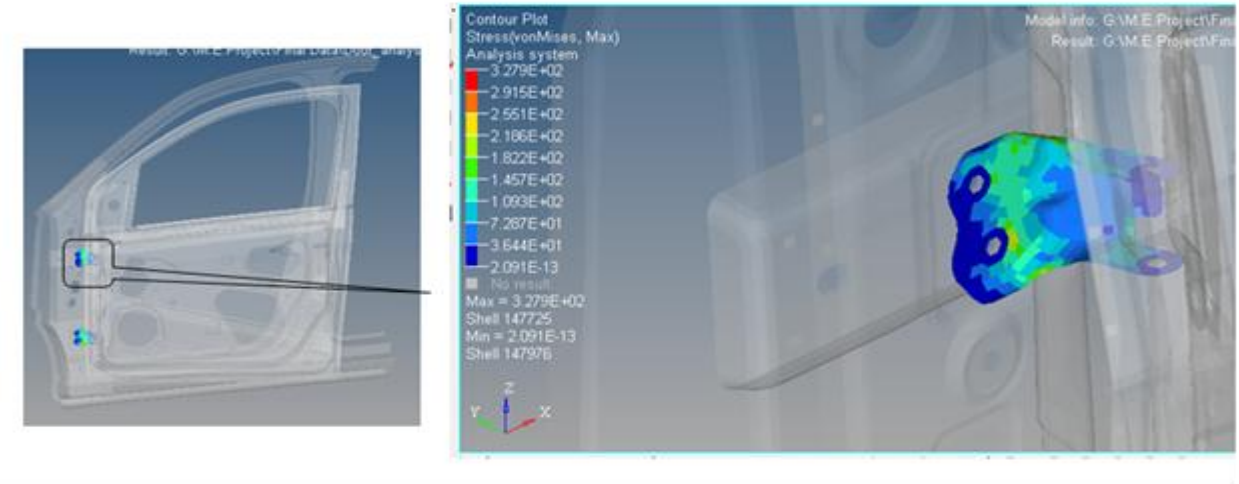

Fig-10 Stress Distribution At Upper Hinge For Worst Load Condition

From above stress plot for upper hinge for worst loading condition we get the maximum induced stress value 327.9N/mm2. And per acceptable criteria for maximum stress for hinge material must be less that 340 N/mm2
We can conclude from above stress plot that the stress induced in current used hinges is much more less those acceptable criteria.

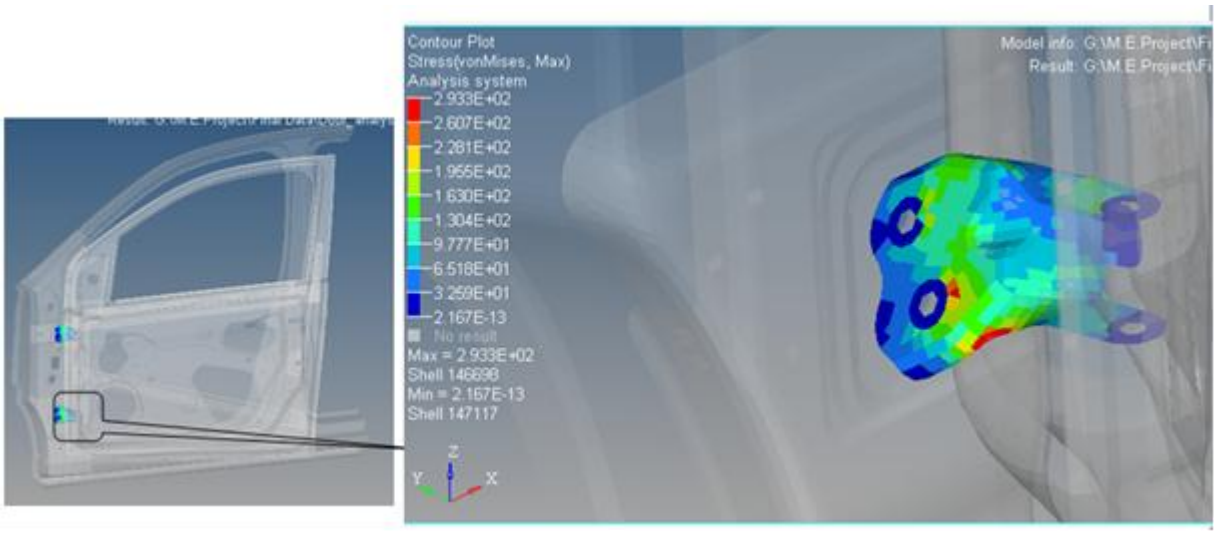

Fig-11 Stress Distribution at Lower Hinge For Worst Load Condition

From above stress plot for lower hinge for worst loading condition we get the maximum induced stress value 293.3N/mm2. And per acceptable criteria for maximum stress for hinge material must be less that 340 N/mm2
We can conclude from above stress plot that the stress induced in current used hinges is much more less those acceptable criteria.

VII. CONCLUSION

As from results of FEA of optimized hinge we can say that the stress and sag performance of optimized hinge satisfies the requirement of allowable displacement at latch point (10mm). Following are the changes that observed in weight changed in Body Side Hinges.

Table 1: Change in weight in body Side Hinge

Thickness (mm)	Weight (Kg)	Change in Weight (Kg)
5mm (Current Designed Hinge)	0.281	0.06 (21%)
4mm (Optimized Designed Hinge)	0.221	

From table we observed that for new optimized hinge we reduced almost 20% weight compare to old one. As we are using four hinges (two LH and two RH) we have reduced the total weight 0.24Kg (240gms) which is almost equal to weight of single hinge.

Also the rear door weight is almost 20-25% less than front door. So we can use same hinges for rear door also. So we can say for eight hinges we have reduced 0.48kg of weight.

Future Scope

As in this paper we have concentrated the optimization on the Body Side Hinges only. There are also some other component like door side hinges, door side hinge reinforcements, body side hinge reinforcement, latch reinforcement can be studies and the performance of of all these components can be optimized.
Also some innovating concepts of door hinges can be incorporated in door design.

REFERENCES

[1]. Practical finite element analysis – Nitin S. Gokhle
[2]. Concepts and applications of finite element analysis – Robert Cook
[3]. Advances in nonlinear finite element analysis of automobiles K.J.Bathe Hypermesh User Guide
[4]. Nastran User Guide
[5]. Altair video training guide
[6]. Paul Dufour, “Introduction of Finite Element Analysis”, (2003).
[7]. A2MAC1 " Vehicle Benchmarking Site"
[8]. Amit Bhagwan, Paul McKune, Timo Faath and Lay Knoerr (2012) "InCar - Advanced Door Design" ThyssenKrupp Steel USA LLC (SAE Technical Paper Series), Volume 5, Issue 1(April 2012) pp 235-246.
[9]. N Jaya Kumar, R P Senthil Kumar and Sajith Nair (2013) "Experimental Approach to Improve the Door Slam Noise Quality in Utility Vehicles" Mahindra & Mahindra Ltd., India (SAE Technical Paper Series), Issue (January 2013) pp 1-8. (2013-26-0095)
[10]. Henrik Adam (1998) "Testing of New Composite Side Door Concepts" (SAE Technical Paper Series), February 23-26, 1998, pp 1-8 (980859)
[11]. S. Baskar, A. Kamat and R. Lange (1998) "Analytical Robust Door Hinge System Design" GM-Midsize and Luxury Car Group (SAE Technical Paper Series) September 29-October 1, 1998, pp 1-5 (982306)
[12]. Raviraj Nayak and Kee Im (2003) "Optimization of the Side Swing Door Closing Effort" General Motors Corporation (SAE Technical Paper Series) March 3-6, 2003 (2003-01-0871)
[13]. Upendra A Deshmukh, Hong Tae Kang and Kalpak Shah (2007) " Design of Dual Sliding Door Mechanism for a Small Sized Car" University of Michigan, Dearborn (SAE Technical Paper Series) April 16-19, 2007 (2007- 01-0461)
[14]. Ki-Chang Kim,Chan-Mook Kim,Jin-Taek Kim (2009) "A Study on the Optimization of Body Structure for Rattle Noise by Exciting Woofer Speakers" Hyundai Motor Company (SAE Technical Paper) (2009-01-2110)
[15]. Anurag gajji and Tarun Gupta (2013) " Efficient and Light Weight Door Panels for Automobiles" Maruti Suzuki India Limited (SAE Technical Paper) August 2013. (2013-01-0374)