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# Design and noise, vibration, harshness analysis of engine bonnet of the car

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**Abstract**
Unique the car auto body have different sort of Bonnet. Bonnet is a vital segment of the auto which is utilized for some reasons. Bonnet is utilized to design the auto include extravagant look. It blankets the motor, radiator and numerous different parts. Subsequently it planned in such a route, to the point bonnet all the support parts ought to be available and it gives a base effect on the motor. At the point when auto over any mischance from the front divide more often than not hood framework gets harmed. So there is a requirement for dissection of bonnet. This paper concentrates on Analysis and strategies utilized for NVH of bonnet.
**Keywords**: NVH, Analysis, car bonnet

## I. INTRODUCTION

The automotive industry is currently spending millions of dollars to improve NVH performance. The new design methods are starting to consider NVH issues throughout the whole design process. This involves integrating extensive modeling, simulation, evaluation, and optimization techniques into the design process to insure both noise and vibration comfort. New materials and techniques are also being developed so that the damping treatments are lighter, cheaper, and more effective.

Noise, Vibration and Harshness, more commonly known as NVH, is an all-encompassing engineering discipline that deals with the objective and subjective structural dynamic and acoustic aspects of automobile design. The NVH engineer is interested in the structural dynamic response of the vehicle from the complete assembled system down to the normal modes of the individual components. As a vehicle is a moving dynamic system, its response to stochastic, time varying inputs is important for safety, quality, and comfort of the passengers.

One specific area of study within NVH is vehicle acoustics. Sound plays an important part in the development of a motor vehicle. Certain aspects of noise produced by a vehicle are controlled by governmental regulations, for example pass-by sound levels or exhaust sound emissio].Other aspects of sound are controlled specifically within the individual company as a method of quality control. Meeting the constantly increasing, and complex needs of the consumer is also a key concern of the NVH program for any vehicle and deserves some specific attention.

Some of the methods used to control noise, vibration, and harshness include the use of different carpeting treatments, the addition of rubber or asphalt material to car panels, gap sealant, and the injection of expandable foam into body panels. The carpeting treatments include varying types of foam padding combined with different weights of rubber-backed carpet. The overall result of this technique is a mass-spring system that acts as a vibration absorber. The rubber or asphalt materials are attached to various car panels to add damping and mass loading to reduce vibration levels and the rattling sounds from the panels. Sealant is applied to close gaps in order to increase the transmission loss from the engine, wind, and road noise sources to the vehicle interior. Expandable foam injected between panels, such as the dashboard and firewall, helps to add stiffness and vibration absorption.

All of these current methods are effective at reducing sound and vibration levels in a vehicle at higher frequencies. However, some of the treatments become almost ineffective at lower frequencies below 200 Hz. The treatments also add a substantial amount of weight to the vehicle, thus affecting its fuel economy, as well as adding cost. Choosing the correct product for your application can be really easy if you properly identify the noise from the start.

There are many contributors to automotive noise and the noise exists across a wide bandwidth of frequencies. To effectively reduce the noise floor within a vehicle, a combination of materials must be used. This technique will result in a greatly reduced installation time, a serious reduction in the amount of added weight to the vehicle and bunch of money saved in your wallet. When trying to reduce or eliminate various types of automotive noise, it is often necessary to utilize a variety of specialized noise control materials.

In the present work a numeric method using finite element is done to evaluate NVH chareterstcs of the door

The finite element analyses is a most useful analysis technique and were widely adopted for the analyses of the component in the form of plates, beams and shell for variety of structure made out of various material. The literature regarding the FEA analysis in prediction/ reduction/ estimation and control of noise and vibration for sound absorbing materials and systems are also of notable quantum. Quite a lot of researchers have highlighted the application and analysis of the sandwich plates, beams and shells. But a few published literature and information are available regarding the analysis of an actual component of a passenger car. Owing to the above discussion, the present investigation are aimed at the modal analysis of component of a passenger car constructed using the conventional material and as well as composite material. The components considered for the analysis of a passenger car are the hood made out of the conventional material and the sandwich constructed components. For modelling and analyses for the NVH character, CATIA v5.0 (for modelling), Altair Hyper Mesh v11.0 (for meshing) and Altair OptiStruct (for modal analysis) are used.

The scope of the present investigation is to create the model of the conventional components, further they are meshed and boundary conditions are applied for different conditions. Finally the meshed models are analysed to find the natural frequencies for different modes. The same components are developed with additional flange structures which are meshed and boundary conditions are applied. The different thicknesses of the sandwich material are adopted and compared with the conventional components. Both conventional and sandwich constructed components with different core thickness are subjected to modal analysis to find the following components and to draw conclusion regarding their NVH characteristics.

## II. Literature review

**A P Gupta** have analysed concentric elliptical nodal lines considering ortho normal polynomials boundary characteristic. In their work they have adopted Rayleigh- Ritz method considering quadraticaly varying thickness controlled by two independent taper constants. The problem was reduced to a standard Eigen value problem. For plates of free, simply-supported and clamped edge condition for various values of aspect ratio, taper, Orthotropy and foundation parameters, frequencies, nodal ellipses and mode shapes for first four modes of vibration were extracted. They suggested that the accuracy of the result can be increased, by increasing the order of approximation which cannot be increased because the results may starts diverting due to rounding off errors.

**K Hosokawa** have analysed free vibration of fully clamped symmetrically laminated skew plate by a numerical approach for a static bending problem. They calculated the natural frequency and studied the effects of the skew angle and fibre orientation angle on natural frequencies and mode shapes. They suggested that the overall bending stiffness was more important than the layer material’s properties with respect to mode shape.

**A Spadoni** et al. in their investigations on structural and acoustic behaviour of chiral truss core beams revealed that unique properties of the chiral geometry and potential benefits of sound transmission reduction and vibration isolation for particular core configuration. They formulated and employed dynamic shape function derived directly from the distributed parameter model of beam elements. The vibro-acoustics performances were evaluated by numerical model which allows an accurate evaluation of the dynamic response at high frequencies with limited number of elements. For a particular incidentpressure wave, the structural acoustics behaviour of the beam was investigated in terms of kinetic energy of the constraining layer in sound pressure level. Square and hexagonal topologies performances were compared with that of the chiral cord which revealed that the complexity of the core geometry appears to affect the response and the mid frequency regions, where the core components usually resonates.

**ZhiweiXu** et al. have conducted an experimental of a particle damping method for beam and plate. A simple and passive means of vibration suppression was done by embedding tungsten carbide particles within longitudinal and latitudinal holes drilled in the structure they have carried out experiments with a number of arrangements of the packed particles with different particle size and volumetric packing ratios. The particle damping conceded was remarkably effective although it was non-linear; a strong rate of energy dissipation was achieved within a broadband range. The damping behaviour was dominated by shear frictional forces between particle layers caused by strain gradient of the structure in the longitudinal and latitudinal directions. Free vibration decay linearly with the particle damping, as a consistent feature with other types of particle dampers. Their study offers an insight in the effectiveness of impact damping.

**P Muthukumaran** et al. have developed method to study the effect of boundary conditioning on vibration behaviour and hence the harmonics of a rectangular plate. They have suggested that the structural and natural frequencies can be manipulated by controlling conditions at the boundaries in a nonhomogeneous and non-uniform fashion. They developed analytical model for a plate type structure to illustrate the boundary conditioning technique. To achieve the required results modification of translational and rotational stiffness distribution on the edge were incorporated.

## III. Methdology

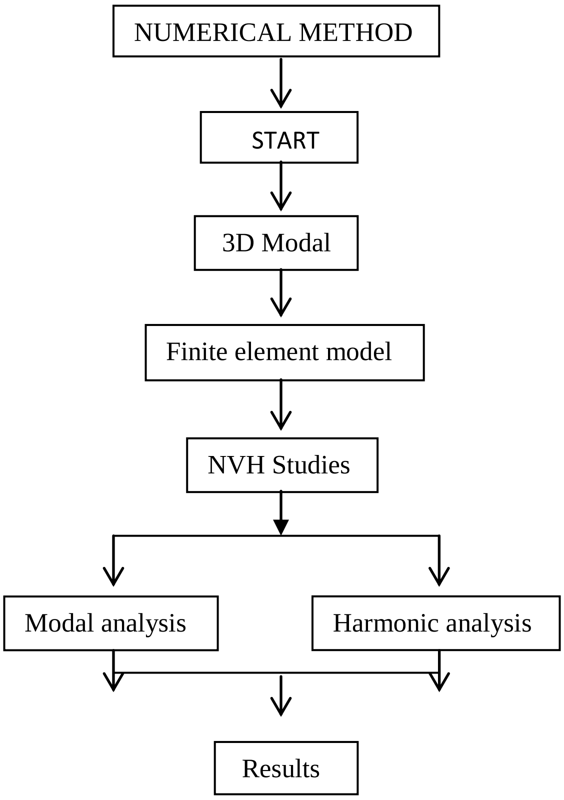


Fig.1 Methdology

## IV. The Bonnet FE Modelling

The modelling of the bonnet before and after modification is done by using catia v5.0. CATIA (Computer Aided Three dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault systems which is one of the world's leading CAD/CAM/CAE package. Being a solid modelling tool, it not only unites 3D with 2D tools, but also addresses every design through manufacturing process. Besides providing an insight in to the design content, the package promotes collaboration between companies and provides them with edge over their competitors. In addition to creating solid models and assemblies, 2D drawing view can also be generated in in the drafting workbench of CATIA. The drawing views that can be generated include orthographic, section, auxiliary, isometric or detailed views. The bidirectional associative nature of this software ensures that the modifications made in the model are reflected in the drawing views and vice versa. This package finds its application in many industries specifically in aerospace and automotive applications.

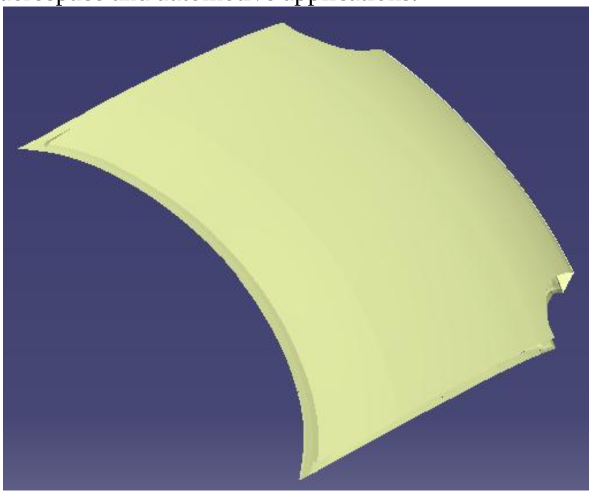

Fig.2. car bonnet catia modal

## V. Meshed modal

The meshing of the bonnet before and after modification is done by using Altair hypermesh v11.0. Altair hypermesh is a high performance finite-element pre-processor for popular finite-element solvers that allows engineers to analyse product design performance in a highly interactive and visual environment. Advanced functionality within Hypermesh allows users to efficiently manipulate geometry and mesh highly complex models. These functionalities include extensive meshing and model control, morphing technology to update existing meshes to new design proposals and mid-surface generation for complex designs with varying wall thicknesses. Solid geometry enhances tetra-meshing and hexa meshing by reducing interactive modelling times. With the broadest set of direct CAD and CAE interfaces coupled with user defined integrations, Hypermesh fits seamlessly within any simulation environment. With both automatic and semi-automatic shell, tetra and hexa meshing capabilities, Hypermesh simplifies the modelling process of complex geometries. A flexible set of morphing tools allows users to modify existing meshes to meet new designs and reduce model development costs. Hypermesh provides direct access to a variety of industry-leading CAD data formats for generating finite element models. Moreover, hypermesh has robust tools to clean up imported geometry containing surfaces with gaps, overlaps and misalignments that prevent high-quality mesh generation .By eliminating misalignments that and holes, and suppressing the boundaries between adjacent surfaces, users can mesh across larger, more logical regions of the model, while improving overall meshing speed and quality. Boundary conditions can be applied to these surfaces for future mapping to underlying element data.

Table:1 General statistics of mesh of car bonnet

| | Car bonnet |
|---|---|
| Number of nodes | 8638 |
| Number of elements | 8454 |
| Spot weld | 312 |
| Elem mass | 309 |
| Mc-battery-tray –beam | 101 |

COMPONETS OF BONNET

1.outer body of bonnet


Fig.4 Image of outer body

2.inner body of bonnet

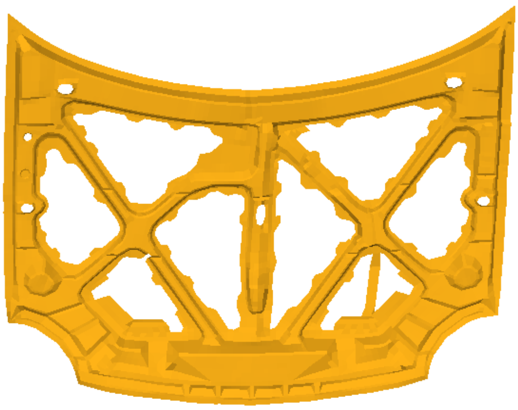

Fig.5 Image of inner body or stiffner

## VI. RESULTS AND DISCUSSION

Modal analysis is used to obtained for natural frequency for bonnet component result extracted for different modes with different condition. And shell elements used.

I: Modal analysis of car bonnet

A. Free-Free without stiffener

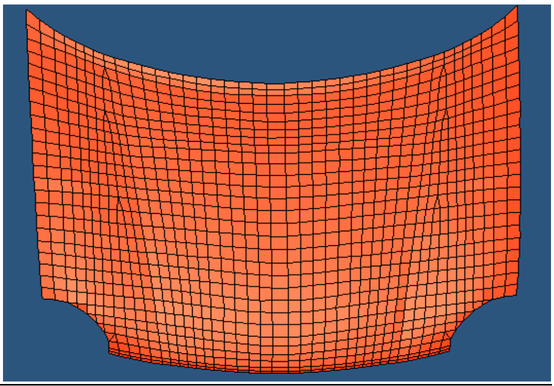

Fig.6 Image of free-free modal analysis

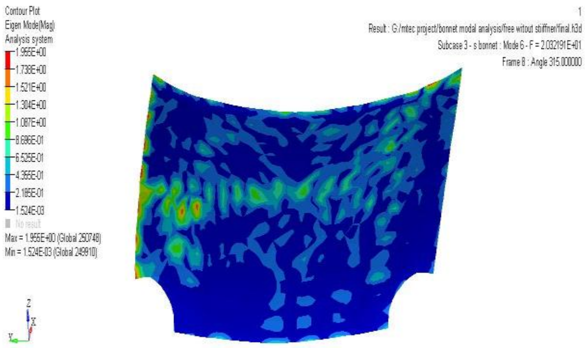

Fig.7 Mode number 6th for free condition.

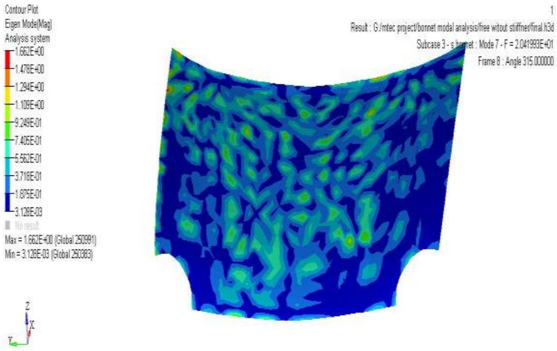

Fig.8 Mode number 7th for free condition

B. Fixed without stiffener

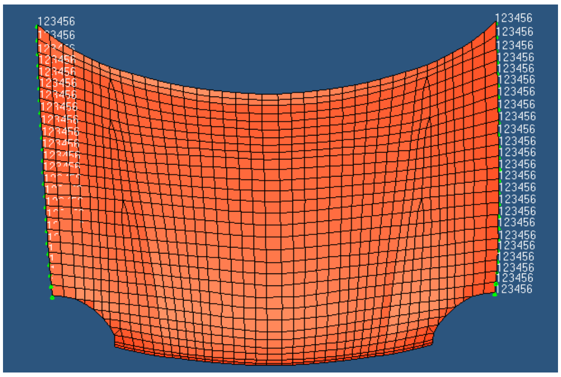

Fig.9 Image of fixed modal analysis

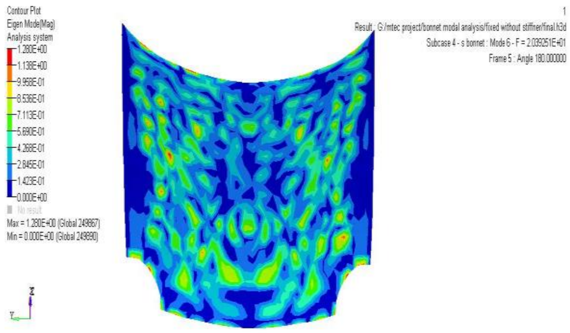

Fig.10 Mode number 6th for fixed condition

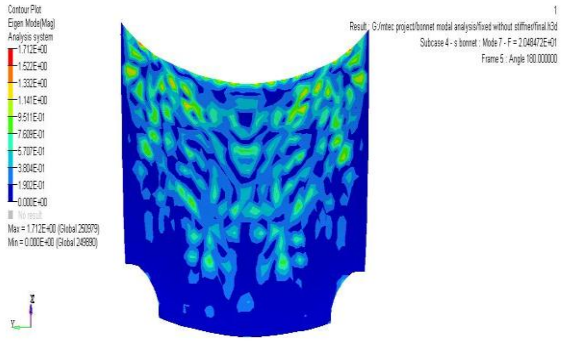

Fig.11 Mode number 7th for fixed condition

C.Free-Free with stiffener

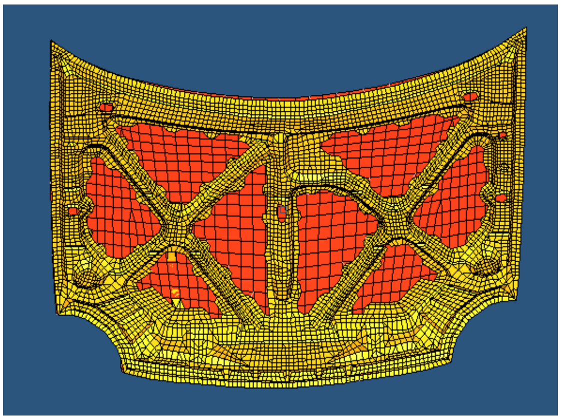

Fig.12Image of free-free modal analysis

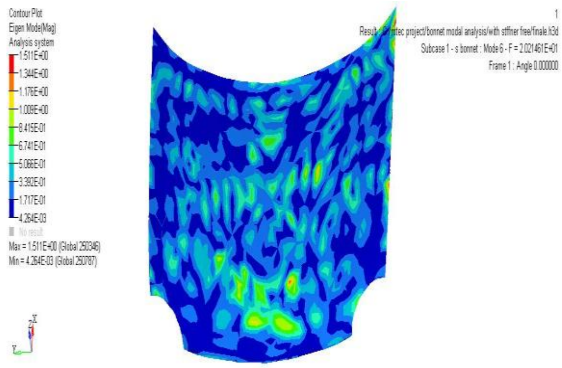

Fig.13 Mode number 6th for free condition.

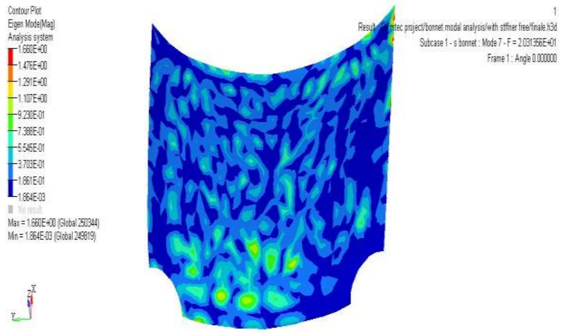

Fig.14 Mode number 7th for free condition

D. Fixed with stiffener

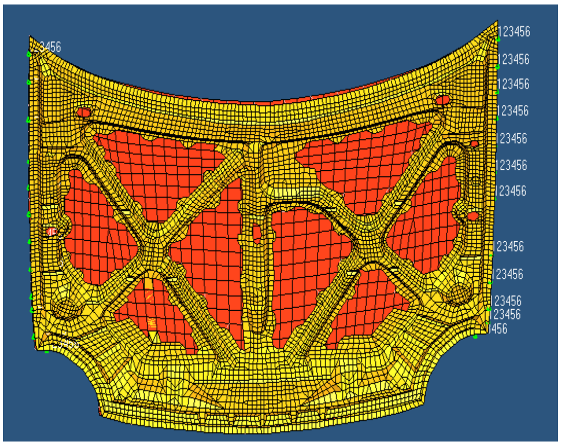

Fig.15 Image of fixed modal analysis

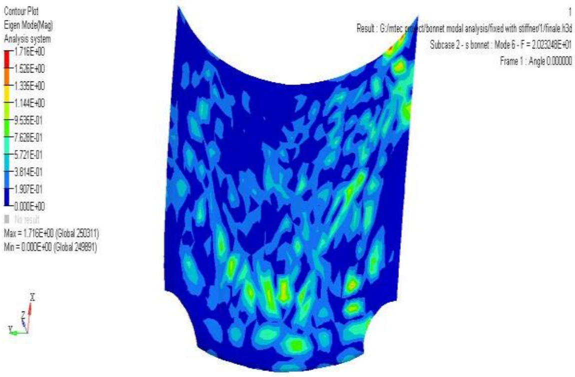

Fig.16 Mode number 6th for fixed condition

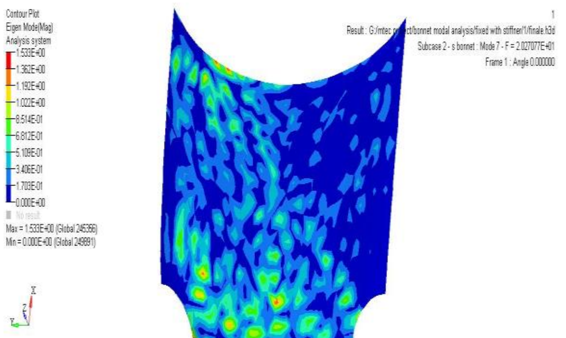

Fig.17 Mode number 7th for fixed condition

In Modal analysis, thetwo types of modes that are local modes while the second modes are global modes. Local Modes shown in fig 7&8 are free free without stiffener oscillates at left side of the bonnet and frequency is 20.32Hz and 20.41Hz respectively. Local Modes shown in fig 10&11 are fixed without stiffener oscillates upper portion of the bonnet and frequency are 20.39Hz and 20.48Hz respectively. In fig 13&14 are free with stiffener oscillates center portion of bonnet and frequency are 20.21Hz and 20.31Hz respectively. In fig 16&17 are fixed with stiffener oscillates at lower portion of bonnet and frequency are 20.23Hz and 20.27.The global modes are out of target and so, indicates that it needs to increase its stiffness This can be achieved by inserting metal partition inside the opening, to increase the local stiffness near lower slide fixing.

. Harmonic analysis of car bonnet

A. without stiffener

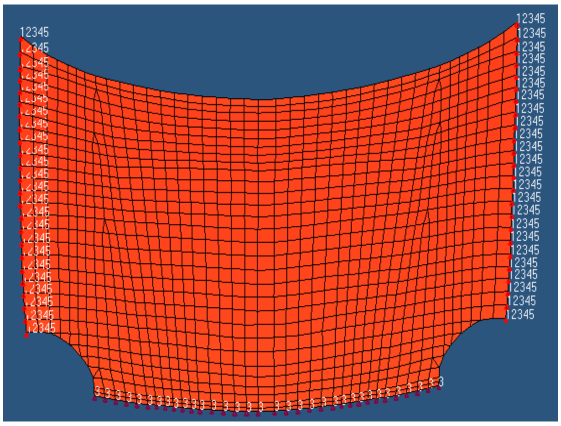

Fig.19 Image of harmonic analysis

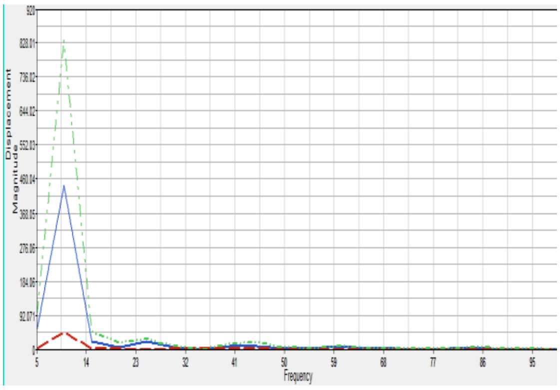

Fig.20 Graph of Displacement vs Frequency

B, with stiffener

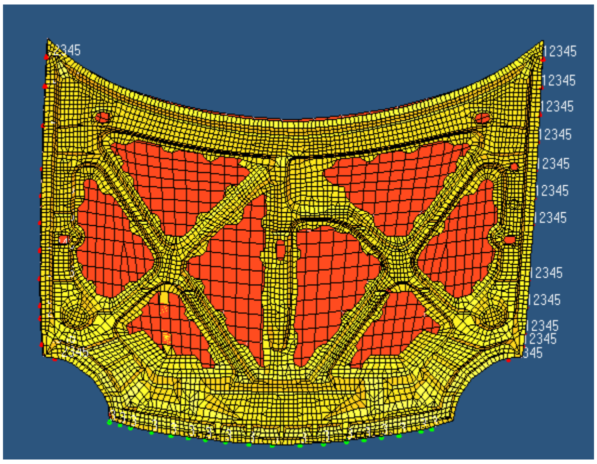

Fig.21Image of harmonic analysis

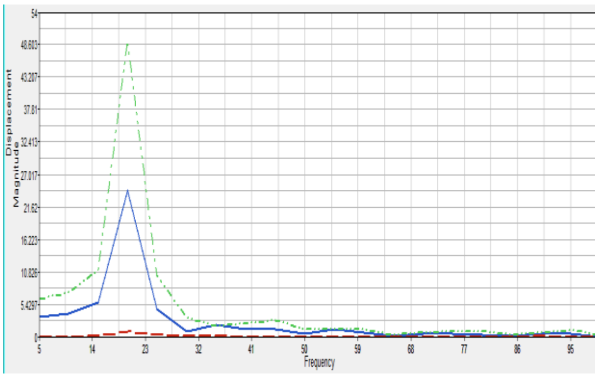

Fig.22 Graph of Displacement vs Frequency

Table2Displacement and Frequency.

| | Without stiffener | With stiffener |
|---|---|---|
| Frequency (Hz) | 12 | 22 |
| Displacement (mm) | 370 | 26 |

From the table 2 without Bonnet stiffener the displacement is 370 mm and with stiffener the displacement is 26 mm and frequencies are almost same so for better design and safety with stiffener is best.

## VII. CONCLUSIONS

The analysis and improvement of a vehicle body structure based on NVH behavior is investigated by fem or numerical method. Firstly, the surface modeling is accomplished for the vehicle body in CATIA and meshed in HYPERMESH software. Then, modal analysis and harmonic analysis in a frequency range between 0-100 Hz is done by HYPERMESH. A frequency map of the vehicle body is extracted and compared with a reference map to identify the defects.

Modal analysis of bonnet reveals that they are in target and results are obtained for different modes. In that first modes are local modes and remaining is global modes. The modal frequencies are obtained is >20 Hz which well away from the engine excitation of 16Hz.This results is for ideal condition of engine.( engine at 1000 rpm and load at ideal ). Harmonic analysis is done with and without stiffener for automotive car Bonnet. In harmonic analysis displacement were obtained for both conditions. With stiffener displacement were less and safe design.

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