Evaluation of Natural Frequency of Car Door with and without Damper using Experimental Method and Validate using Numerical Method

Neelappagowda Jagali[1], Chandru B. T[2], Dr.Maruthi B. H[3], Dr.Suresh P.M[4]

1 PG Student, neelumech6@gmail.com, 2 Associate Professors, 3 Professor & HOD

1,2,3 Department Of Mechanical Engineering,

East West Institute Of Technology Bengaluru,

4 Professor & HOD, KSIT Bengaluru.

Karnataka, India.

Abstract- **Up gradation of ride quality and comfortably of the vehicle is the most important for the passengers. These two things can be done by the reduction of vibration and by improving the fatigue life of the parts are concerned . noise can also be reduced with the reduction of vibration. Here in our project, the results as vibration of car door has to be generated by the two methods that is FEA and EMA and these results are compared. Primarily our project head towards the generation of vibration characteristics such as frequency, damping factors and modeling from FEA method. Where we model the door with the use of the software known as CATIA. Then this is extracted by HYPERMESH software for meshing the component. ABAQUS solver solves the mesh component with boundary conditions. The next stage is where we take the characteristics results of car door by the another method EMA where the use of FFT analyzer with the combination of ME Scope software is made. Then the comparison of these results of FEA and EMA plays an important role for the determination of vibration characteristics for the optimization.**

Key word: **catia, hyper mesh, ABAQUS, frequency.**

1. INTRODUCTION

Liberalization and Globalization has bought paradigm shift for the industrialized countries. A large number of automobile industries started operating and rolled out number of variants of passenger and commercial vehicles and posed challenges to the existing car manufactures and as well as reached the larger population of most of the countries. At the same time most of the countries who are striving to achieve the tag developed country opened up themselves, invited the other countries to invest with them so as to achieve economic growth, improving per capita income and hence to bring improve life style and better social status of their countrymen. Above scenario brought changes in the world and opened up large avenues and registered growth. As a result the per capita purchasing power of the countries increased and it became a boon for the manufacturer and industries of the consumer durables. The above reflected in increased energy demands and led to the problem Global Energy Crisis. The Governments concentrated in addressing the energy problem by formulating regulation and policies, one such is fuel efficient vehicle.

The automotive industry is currently spending millions of rupees on Noise, Vibration and Harshness (NVH) work to develop new materials and damping techniques. In that mainly vibration analysis of an automotive component is used to determine the vibration produced on the component which is due to running condition of engine or due to the force transmitted from the ground to various parts. Vibration analysis finds its application in automotive industries and also in aerospace industries. The automobile and aeronautical industries took this challenge and explored intensively and finally centered on the vibration analysis method and also on material type to achieve the object of fuel efficient vehicle. These new energy efficient vehicles reached the market with lot of queries regarding safety, comfort of the passenger and also their durability and life. Due to fierce competition in the automobile industry, product development time and cost for an automobile is reduced drastically. This has put the limitation on the number of prototypes and number of vibration tests that are required to be performed. In developing automobiles, the mode of Vibration problems varies significantly depending on engine and chassis types, with many problems occurring only in completed vehicles.

In addition, the Vibration problems to be solved during development of a particular car require many hours of work and pose a significant challenge in expediting vehicle design completion. Furthermore, since the Vibration problems of a given vehicle are often the result of complex mechanisms, determination of the root causes of a Vibration problem through experiments with actual vehicles is very difficult. Different types of techniques used to help identify Vibration include part substitution, modal analysis. Most Vibration work is done in the frequency domain, using Fast Fourier Transforms to convert the time domain signals into the frequency domain. Wavelet analysis, order analysis, statistical energy analysis, and subjective evaluation of signals modified in real time are also used. The new design methods are starting to consider Vibration 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. With the developments in the technology of FE model updating, vibration test on only one prototype is sufficient to design the structure for dynamic soundness. In this project component is experimentally analyzed using an impact hammer that produce a frequency in the range of 0-200 Hz, the frequency response function (FRF) of the body is calculated by a software named Text express to get the dynamic behavior of the auto–body structure; the instrument that is used in our experiment is LMS CadaX which convert the pressure energy in to digital signal represented by sinusoidal graph; various experimental result like damping frequency, natural frequency and mode shapes are obtained. Currently, Carbon Fiber is the material extensively used as car body in the expensive car due to its excellent property like light weight and strength.

METHODOLOGY

Methodology is define as the successive step by step process of manufacturing or designing of component or solving problem etc.

Here in our project we are analyzing the door by two methodology those are FEA and EMA.

- In this FEA analysis method we proceeding by the following steps
    - Creating 3D modal
    - Meshing
    - Analysis
    - Post-processing
    - Result
- In EMA method following are the steps used
    - Car door
    - Marking required number of points
    - Hitting on the marked points by hammer
    - Data analysis
    - Extracting frequencies, damping factor and mode shapes.
    - Results

WORK CARRIED OUT IN FINITE ELEMENT METHOD.

Geometry

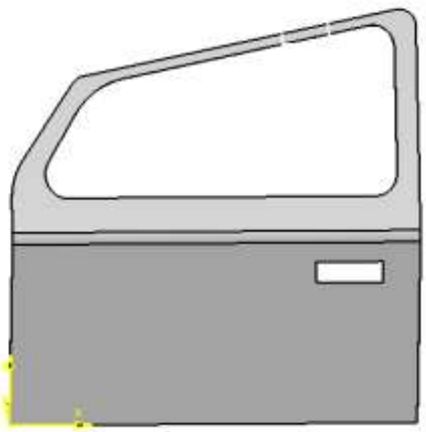

Figure 1: car door catia model.

The primary requirement of the FEA is the geometry of the part which is generated by using the software known as CATIA V5 R20, CATIA is as multiplatform CAD/CAM/CAE software suite developed by the French company Dassault system. This software helps used in the creation of the geometry very accurately with the use friendly commands for the better modal.

Meshing

Figure 2: meshed car door model.

The approximation of geometry domain in the form polygonal or polyhedral mesh is known as mesh generation. In 3-D meshing used in FEA contains tetrahedral, pyramids, prisms or hexahedral. Meshing can be defines as discretization for 1-D, 2-D and 3-D.

The HYPERMESH tool is used for meshing of door. Finite element quality is the suitable which is used for meshing. 15205 and 15190 are the total number of elements and nodes respectively used for the generation of FE modal.

Table: 1 List Of Number Of Nodes And Elements During Meshing

Nodes	15205
Elements	15190
Mesh type	SHELL

Table : 2 Shows The List Of Material Properties Of Steel.

Properties	Values
Young’s modulus	210E3 N/mm^2
Density	7.9E-6 kg/mm^3
Poisson’s ratio	0.3
Thickness	0.75 mm

Numerical Analysis

The external vibration which are excreted on the structure, deforms the structure which can be described by the method known as modal analysis. The deformation of the structure is in the form of number of well deformed wave like shapes or of the form of modes. Each mode exhibits its own frequency, mode shape and damping factor.
Here we are determining the frequency , mode shape and damping factor for the structure on the basis of different conditions like

- **free-free condition**

The above condition we have to deal with damper and without damper. Ultimately we have to compare the results of FEA and EMA for the optimization.

FE METHODE RESULTS ON FREE-FREE CONDITION WITHOUT DAMPER

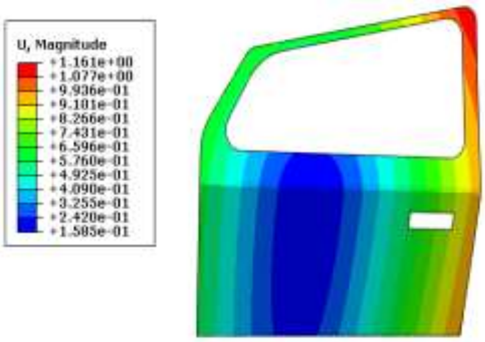

Figure 3: 7th Mode Shape And Frequency Is 43.51Hz In Free-Free Condition Without Damper.

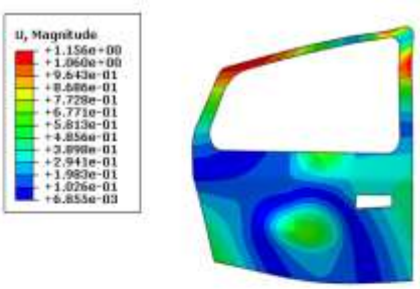

Figure 4: 8th Mode Shape And Frequency is 67.22 Hz in Free-Free Condition Without Damper.

Table: 3 Shows Frequencies Of Free- Free Mode Without Damper

Without damper	
Mode shape number	Frequency(Hz)
7	43.51
8	67.22

FE METHOD RESULTS ON FREE-FREE CONDITION WITH DAMPER

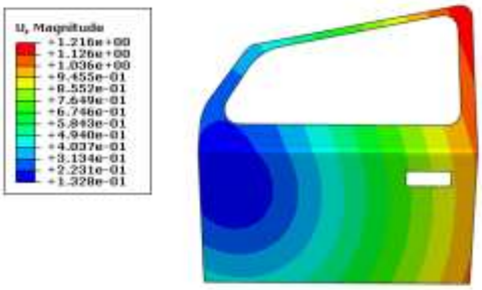

Figure 5: 7th Mode Shape And Frequency Is 40.01 Hz In Free-Free Condition With Damper.

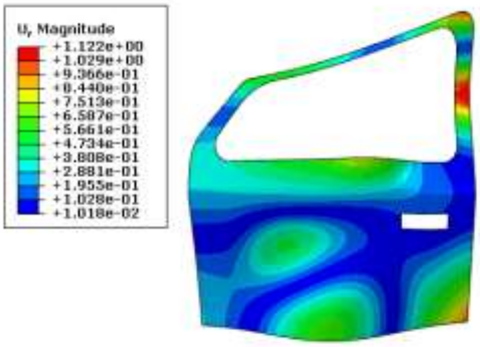

Figure 6: 8th Mode Shape And Frequency Is 57.41 Hz In Free-Free Condition With Damper.

Table: 4 Shows Frequencies Of Free- Free Mode With Damper

With Damper	
Mode Shape Number	Frequency(Hz)
7	40.01
8	57.41

WORK CARRIED IN EXPERIMENTAL ANALYSIS

Figure 7: Shows The Experimental setup Of Car Door.

Experimental modal analysis, also known as modal analysis or modal testing, deals with the determination of natural frequencies damping ratios, and mode shapes through vibration testing. Two basic ideas are involved:

In the wake of hanging the door part, on the surface of segment denoted the focuses to measure the characteristic frequencies (there are 130 focuses set apart in the door surface). A smaller than usual accelerometer is altered at certain reference point (here reference point is 70) for the arrangement of FRF's estimation. Accelerometer is associated with DSA (Digital Signal Analyzer) through channel and other channel to pound. The entire setup is associated with Laptop or PC to complete the investigation, in Laptop or PC the ME scope programming ought to introduced right on time before begin of investigation. This courses of action of trial is appeared in figure underneath

RESULTS ON FREE-FREE CONDITION WITHOUT DAMPER

Figure 8: 7th Mode Shape And Frequency Is 53.7 Hz In Free-Free Condition Without Damper.

Figure 9: 8th Mode Shape And Frequency Is 62 Hz In Free-Free Condition Without Damper.

Table: 5: Shows Frequencies Of Free- Free Mode Without Damper

Without Damper	
Mode Shape Number	Frequency(Hz)
7	53.7
8	62

RESULTS ON FREE-FREE CONDITION WITH DAMPER

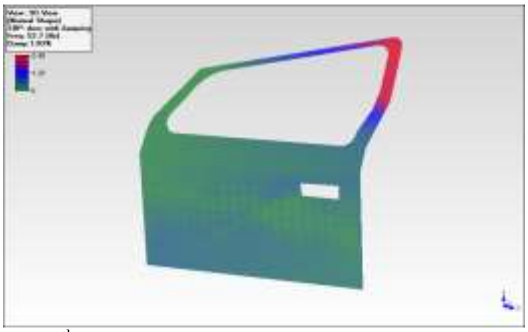

Figure 10: 7th Mode Shape And Frequency Is 52.7 Hz In Free-Free Condition With Damper.

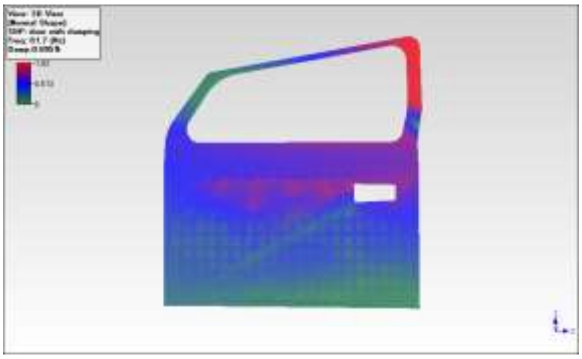

Figure 11: 8th Mode Shape And Frequency Is 61.7 Hz In Free-Free Condition Without Damper.

Table: 6: Shows Frequencies Of Free -Free Mode With Damper

With Damper	
Mode Shape Number	Frequency(Hz)
7	52.7
8	61.7

CONCLUSION

Under free-free condition the basic frequency were very less up to mode six for door indicating the rigid body motion of the structure those modes includes three translator and Rotational modes in respective axis that is X, Y&Z .

From the two conditions with damper and without damper the frequency values obtained from the FE method and experimental method are compared due to decreases in the frequency values the vibration of the component decreases and also due to decrease in the vibration automatically and noise of the component also decreases.

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