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Vibration Analysis of Car Door Using FE and Experimental Technique

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Abstract - *The scope of the project is to observation on the recent trends and latest growth in the ground of experimental modal analysis. To reduce the vibration in car door, there are two methods in the analysis that is modal analysis through FEM technique and experimental analysis through FFT analyzer.*

First, to take out the FEM technique, the car door is created by using software called CATIA V5 R20 and analysis is carried out using software called Hyper works 12.0, FEM technique is done by free- free analysis method to acquire the different frequencies and mode shapes at different nodes. The analysis is carried out in two ways, with stiffener and without stiffener; the stiffener is used to reduce the vibration of an element. The Opti-struct solver is used to get the natural frequency.

Second, modal analysis is done experimentally through FFT analyzer to attain the results of frequencies and mode shapes.

Third, to reduce the vibration one of the technique used to altering frequency of the structure by adding stiffener to car door structure, again free-free modal analysis is done in FFT analyzer technique with stiffener condition. And finally compare the obtained results.

Key Words: FEM technique, FFT analyzer, free- free analysis, frequencies, mode shapes.

1. INTRODUCTION

Noise Vibration Harshness (NVH) is used to conclude the vibration produced on the component in different applications like automotive and aerospace parts. In automotive parts vibrations are owing to the road surface environment, rotations of the machine and resources used. The created vibrations will be transferred to the automotive body parts which generates irritation to the driver and the occupants. In addition lack of comfort and safety, this can be reduced such as add or decreasing the stiffness by squeeze in the damping materials between metals and also switching to composite materials.

Vibration can be reduced by adding stiffeners on door component where maximum tip of vibrations are plot in the graphs in FEM investigation for Free-free conditions testing were performed and comparison of frequencies was done.

Door: Door is a shielding envelops fixed at the right and left side of the body casing, it shields against wind, dust etc and it also Noise inhibiter and aerodynamic shape will also assist the performance of the vehicle.

It is pivoted at the frontend and fastened at the rear of body casing of the components of the passenger car also maintain crush opposition. Assembly should not divide when subjected to longitudinal loads and inertia loads applied to the system without disconnect from the fastened position. The hinges of the door must sustain longitudinal and transverse loads.

2. METHODOLOGY

The methodology of experimentation of flow chart is shown in figure.1.

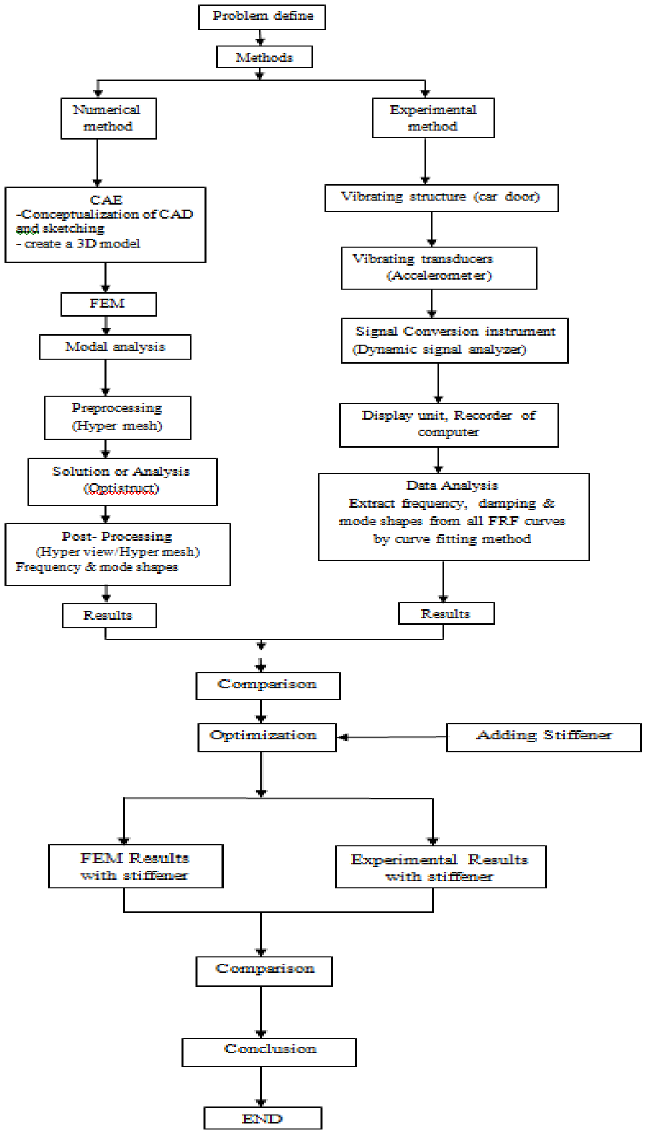

Figure.1. Methodology flow chart

Figure.2. Model of car door

The model formed by means of modelling tool, here we used Catia V5 and are export to meshing, this is completed by Hyper-mesh and Opti-Strut is the solver, experimental analysis is also carried out.

Modelling: Model of car door was taken out from Vehicle body casing analysis library where all the geometry of automotive components are accessible.

FE analysis: Numerical Analysis is a powerful technique of modelling intricate structures and used as a design tool, by isolating the structure into a number of tiny parts called as Finite elements, every element has a limit point is called node that are adjoining to the elements.

The limit conditions adopted was Free- Free and constrained for which door was constrained as pivoted at one end and fastened at the other end and authenticated the results using with and without stiffener shown in table-4.

Door material property: Door is a shielding envelop for the engine and other components in the passenger car. It also acts a significant role in aerodynamics. The steel used for door component is SCGA (steel cold rolled galv annealed) including as specified in Table.1.

Table.1. steel composition

Types of Metal	Percentage (%)
Carbon (C)	0.05-0.25
Silicon (Si)	2
Manganese (Mn)	1-3
Phosphorous (P)	0.1
Sulphur (S)	0.01
Nitrogen (N)	0.005
Chromium (Cr)	1
Vanadium (V)	1
Molybdenum (Mo)	1
Aluminium (Al)	0.3-2
Titanium (Ti)	0.005
Niobium (Nb)	0.005
Iron (Fe)	Remaining

Finite element model

The meshed or FEM model is as shown in figure.3

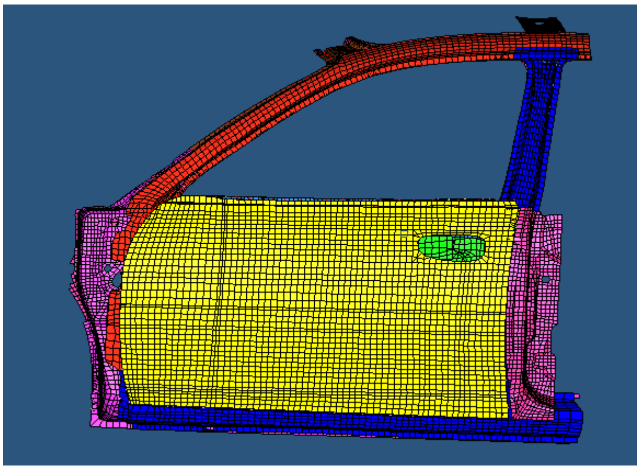

Figure.3. Meshed model of car door

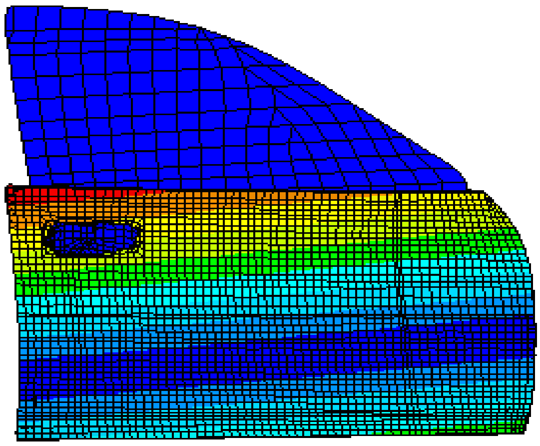

Figure.4. At mode-7 for free-free condition without stiffener

Figure.5. At mode -7 for free-free condition with stiffener

Table.2. Comparison of frequencies with and without stiffener

Modes	Frequencies without stiffener in Hz	Frequencies with stiffener in Hz
7	34.2	35.0
8	43.1	44.5
9	66.3	67
10	76	77.5

3. RESULTS

Experimental modal analysis also known as modal analysis or modal testing, deals with the calculate tip values of vibrations in the graphs of natural frequencies, damping ratios and mode shapes during vibration testing. Two necessary ideas are involved.

Figure.6. Experimental modal analysis measuring instruments

The necessary equipment: a) An exciter or source of vibration to apply a known input force to the door (Impact hammer), b) A transducer to convert the physical motion of the door to an analog signal (Accelerometer), c) An amplifier to make the transducer characteristics, d) The digital data acquisition system, e) An analyzer to perform the task of signal processing and modal analysis using suitable software.

Table.3. Frequencies for free-free Modal analysis

Mode numbers	Frequency Hz
1	0.000032
2	0.000034
3	0.000035
4	0.000036
5	0.000036
6	0.000038
7	34.2
8	43.1
9	66.3
10	76

The result of these equations becomes more intricate when the degrees of freedom of the system are huge or when the forcing functions are non-periodic. In such cases, a more suitable technique known as modal analysis can be used to resolve the problem.
To determine the values of the component, nodes were marked around the component at equi-distant, the accelerometer was mounted at the suitable position of the component this is coupled to the analyzer, using the impact hammer is impacted with a slight force due to excitation graphs are on the analyser. In addition it is examined for the constrained condition to calculate the frequencies, modes and mode shapes. Shapes either in numerical or graphical form results are in Table.3.

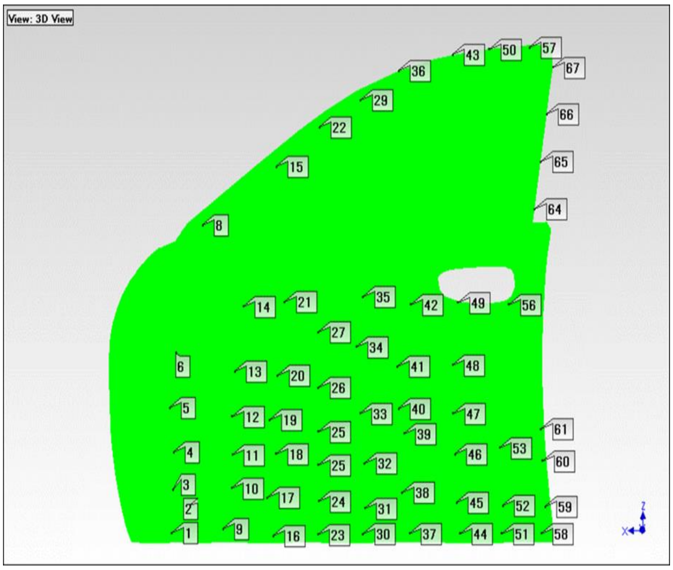

Figure.7. Element numbering using ME scope

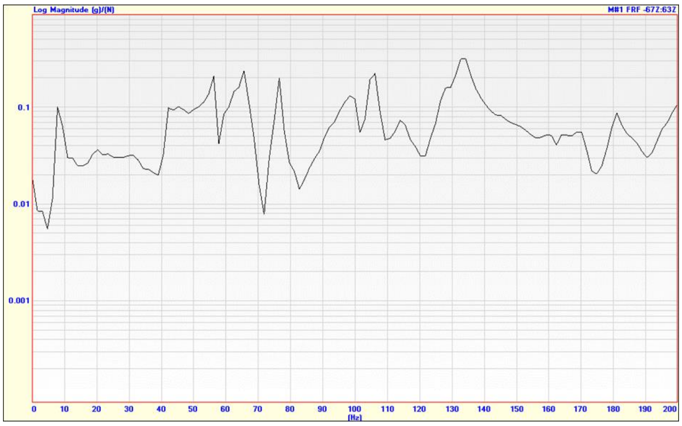

Figure.8. Frequency at node 7

Table.4. FFT analyzer Results of without stiffener

Select Shape	Frequency (or Time)	Damping	Units	Damping %
1	32.4	0.986	(HZ)	3.05
2	42.6	0.609	(HZ)	1.43
3	64.5	1.08	(HZ)	1.68
4	76.2	0.63	(HZ)	0.826
5	91.9	1.3	(HZ)	1.41

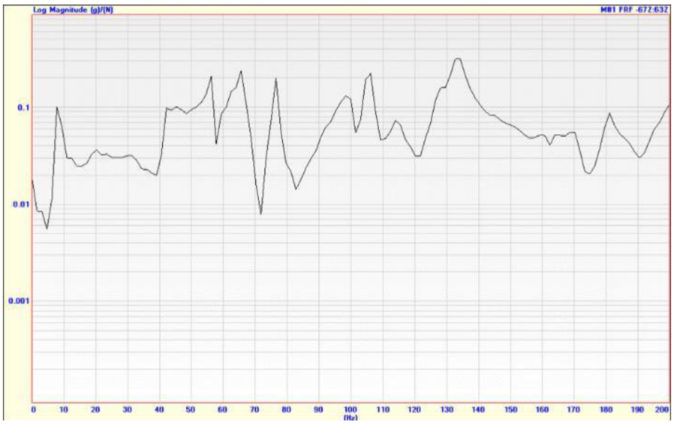

Figure.9. Comparison of the frequency before and after alteration

Table.5. Comparing the frequency before and after alteration

Mode numbers	Frequency with stiffener (Hz)	Frequency without stiffener (Hz)
7	62.5	67.7
8	75.1	78.2
9	105.2	105.3
10	66.2	67.2

Results which are obtained by Numerical analysis and by the experimental are co –relating and within the limits.

4. CONCLUSIONS

Accomplished both Experimentally and Finite Element analysis using with and without stiffener for the Free- Free conditions, it is concluded that there will be significant vibration decrease can be seen from the 7th mode to 10th mode .Hence the improvement in the natural frequencies and damping characteristics.

5. SCOPE OF FUTURE WORK

By using damping material vibration can be reduced, by adding aluminum stiffener vibration can be reduced, by using magnesium material as a stiffener vibration can be reduced efficiently.

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