Finite Element and Experimental Modal Analysis of Car Door

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ABSTRACT

Noise which is developed in the automotive body components due to many reasons, the component was extracted from automotive body components Library, meshed using Hyper mesh and further Modal analysis was carried out using Opti strut using with and without stiffeners. The frequency was extracted for Free and constrained conditions. Harmonic Analysis and Experimental modal analysis was carried out for validation of results.

KEY WORDS: FE analysis free condition, Harmonic Analysis, Experimental modal analysis.

1. INTRODUCTION

Noise Vibration (NVH) in various area like automotive and aerospace components. In automotive components vibrations are due to the road surface conditions, revolutions of the engine and materials used. The generated vibrations will be transferred to the body components which produces annoyance to the driver and the occupants. Also lack of comfort and safety, this can be reduced such as add or decreasing the stiffness by sandwiching the damping materials between metals and also switching to composite materials.

Vibration reduction can be reduced by adding stiffeners on door component where maximum peaks of vibrations are plotted in the graphs in FE analysis for Free-free conditions testing was conducted and comparison of frequencies was done.

Door: Door is a protective cover fitted at the right and left side of the body frame, it protects against wind dust etc, and it also Noise inhibiter and aerodynamic dynamic shape will also help the performance of the vehicle.

It is hinged at the frontend and latched at the rear of body frame of the components of the passenger car also sustain crush resistance. Assembly should not separate when subjected to longitudinal loads and inertia loads applied to the system without disengaging from the latched position. The hinges of the door must support longitudinal and transverse loads.

2. METHODOLOGY

The methodology of experiment of flow chart is shown in fig1.

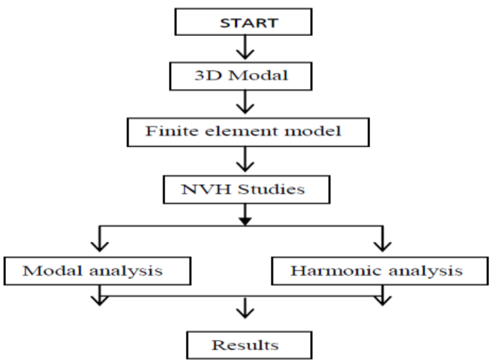

Figure.1. flow chart methodology

Figure.2. Model of car Door

The model created using modelling tool, here we used Catia V5 is and is export to meshing, this is done by Hyper mesh and Opti Strut is the solver, Harmonic analysis is also carried out and experimental analysis is conducted.

Modelling: Model of car door was extracted from Vehicle body frame analysis library where all the geometry of automotive components are available.

FE analysis: Numerical Analysis is a powerful method of modelling complex structures and used as a design tool, by dividing the structure into a number of small parts called as Finite elements, each element has a boundary point is called node that are adjacent to the elements.

The boundary conditions adopted was Free- Free and constrained for which door was constrained as hinged at one end and latched at the other end a n validated the results using with and without stiffener shown in table-4.

Door material property: Door is a protective covering for the engine and other components in the passenger car. It also plays an important role in aerodynamics. The steel used for door material is SCGA (steel cold rolled galv annealed) containing as given in table-1.

Table.1. steel composition

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

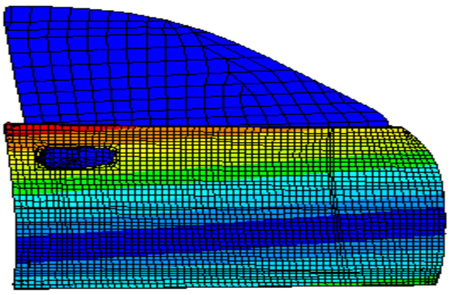

Figure.3. At mode-7 for free-free condition without stiffener

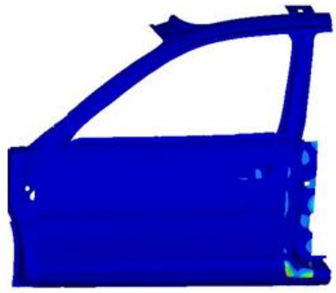

Figure.4. At mode -7 for free-free condition with stiffener

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

Harmonic analysis: This is also one method to check the mode shape of the any vibrating components,using meshing softeware and hormonic analysis tool as a solver, analysis of With and Without stiffener were carried.

Simple harmonic analysis is performed for two different condition: Car door fixed without stiffener, Car door fixed with stiffener

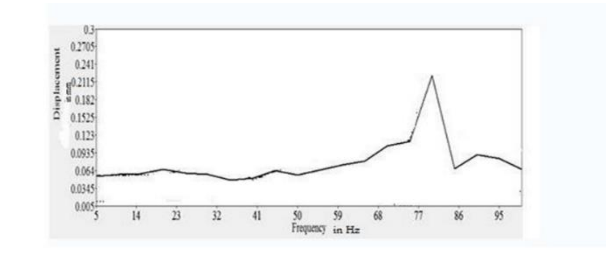

Figure.5. Harmonic analysis of door without stiffener

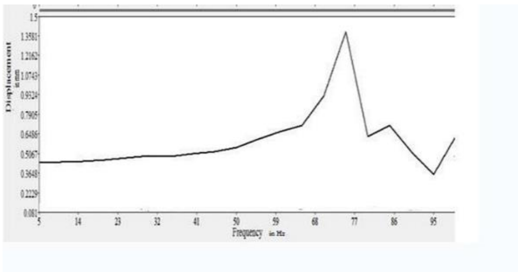

Figure.6. Harmonic analysis of car door with stiffener

Table.3. Comparison of without and with stiffeners in Harmonic motions.

Parameters	Without Stiffener in Hz	With stiffener in Hz
Frequency (Hz)	73	75
Displacement (mm)	1.3	0.175

3. RESULTS

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

Figure.7. 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.4. Frequencies for free-free Modal analysis

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

The solution of these equations becomes more complex when the degrees of freedom of the system are large or when the forcing functions are non-periodic. In such cases, a more convenient method known as modal analysis can be used to solve the problem.

To measure the values of the component, nodes were marked around the component at equi-distant, the accelerometer was mounted at the convenient location of the component this is connected analyser, using the impact hammer is impacted with a little force due to excitation graphs are on the analyser. Further it is analysed for the constrained condition to evaluate the frequencies, modes and mode shapes.

Exciter: The exciter may be an electromagnetic shaker or an impact hammer. Electromagnetic shaker is the input force so that the response can be measured easily.

Transducer: Among the transducer, it is designed to produce signal proportional to either force or acceleration. Strain gauge can also be used to measure the vibration response of a system.

Signal conditioner: Since the output impedance of transducer is signal conditioner, in the form of charge or voltage amplifiers are used to match and amplify the signals analysis.

Analyser: The response signal, after conditioning, is sent to an analyser for signal processing. Such an analyser receives antilog voltage signals (representing displacement, velocity, acceleration, strain, or force) from a signal conditioning amplifier, shapes either in numerical or graphical form results are in table4.

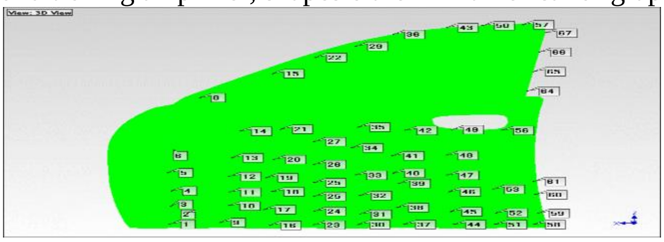

Figure.8. Element numbering using ME scope

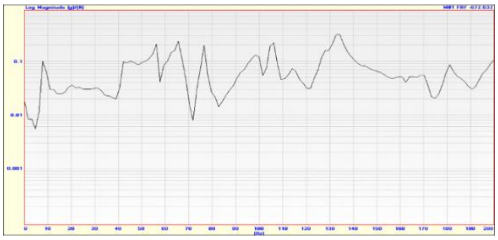

Figure.9. Frequency at node 7

Table.5. FFT analyser Results of without stiffener

Select Shape	Frequency (or Time)	Damping	Units	Damping %	Label Global-Poly	HPC
1	32.4	0.986	(HZ)	3.05	26.6-35.9	0.448
2	42.6	0.609	(HZ)	1.43	37.5-46.9	0.906
3	64.5	1.08	(HZ)	1.68	59.4-68.8	0.83
4	76.2	0.63	(HZ)	0.826	73.4-81.3	0.947
5	91.9	1.3	(HZ)	1.41	87.5-95.3	0.903

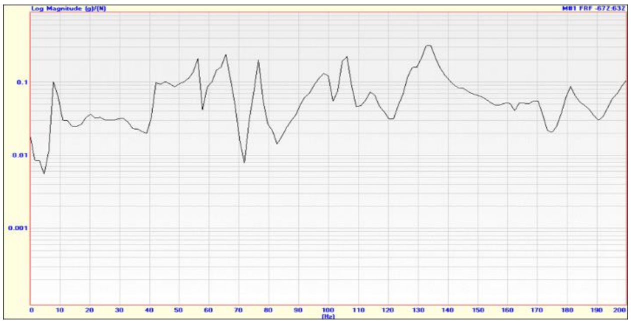

Figure.10. Comparison of the frequency before and after modification

Table.6. Comparing the frequency before and after modification

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 Harmonic Analysis and by the experiments are co – relating and within the limits.

4. CONCLUSION

Conducted both Experimentally and Finite Element analysis using with and without stiffener for the Free-Free conditions, it is observed that there will be significant vibration reduction can be seen from the 7th mode to 10th mode and 11th mode.

Hence the improvement in the natural frequencies and damping characteristics.

Future Scope: 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 effectively.

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