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Optimization and NVH Analysis of Instrument Cluster - A Review

Vijay Raghunath Darade[1], Bala Bhaskar Rao Gamini[2], Prof. M.M.Ghadmode[3]
[1,3]Amrutvahini College of Engineering, Sangamner, Pune University, Maharashtra
[2]Lead Analyst, CAE, Visteon Engineering Center India, Pune -18

Abstract: This paper deals with the study of NVH or Natural Frequency Analysis of an Instrument Cluster. Optimization demonstrates its potential benefits when it is used in the early product design stage. However, many optimization applications for real-world problems are not straightforward, especially in resolving product issues and meeting product design and Manufacturing requirements. Product cost and quality are two vital concerns in product design processes. On the other hand, design optimization provides great opportunities to reduce product cost and improve product performance. Instrument cluster is an Electronics device under driver information category which is used to inform driver and passenger the various condition of vehicle through light emission and pointer gauges. The various information are speed of vehicle, fuel level indicator, temperature of engine coolant, taco-meter, warning symbols such as door ajar, engine check, seat belt etc.

Keywords: Natural Frequency, Vibration Analysis, Instrument Cluster, Topology Optimization, CAE, NVH.

I INTRODUCTION

Introduction to Instrument Cluster

Instrument Cluster is an electronic device to inform driver of various condition of vehicle through light emission & pointer gauges. The core technology of instrument cluster is to collect analog & digital signals from various locations of the vehicle and process the same in the electronic circuit & output the signal in required form such as light, electromechanical gauges & LCD. Examples of various conditions are: speed of vehicle, fuel level in fuel tank, temperature of the engine, speed of the crank shaft, warning signals- parking brake, door ajar, ABS, Tell-tale signals- Right/Left turn signals, Gear engagement. In most of cases Instrument Cluster is located in the Instrument panel & exactly in front of the driver & behind the steering wheel so that it is clearly visible. While mounting the Instrument cluster proper care should be taken like no external light should reflect from the lens & fall on the eye of driver. Also all the critical signals should be clearly visible through the opening of the steering wheel. [1]

Fig.1.1 Picture of Honda Ridgeline Instrument Cluster. [1]

II PROCESS METHODOLOGY

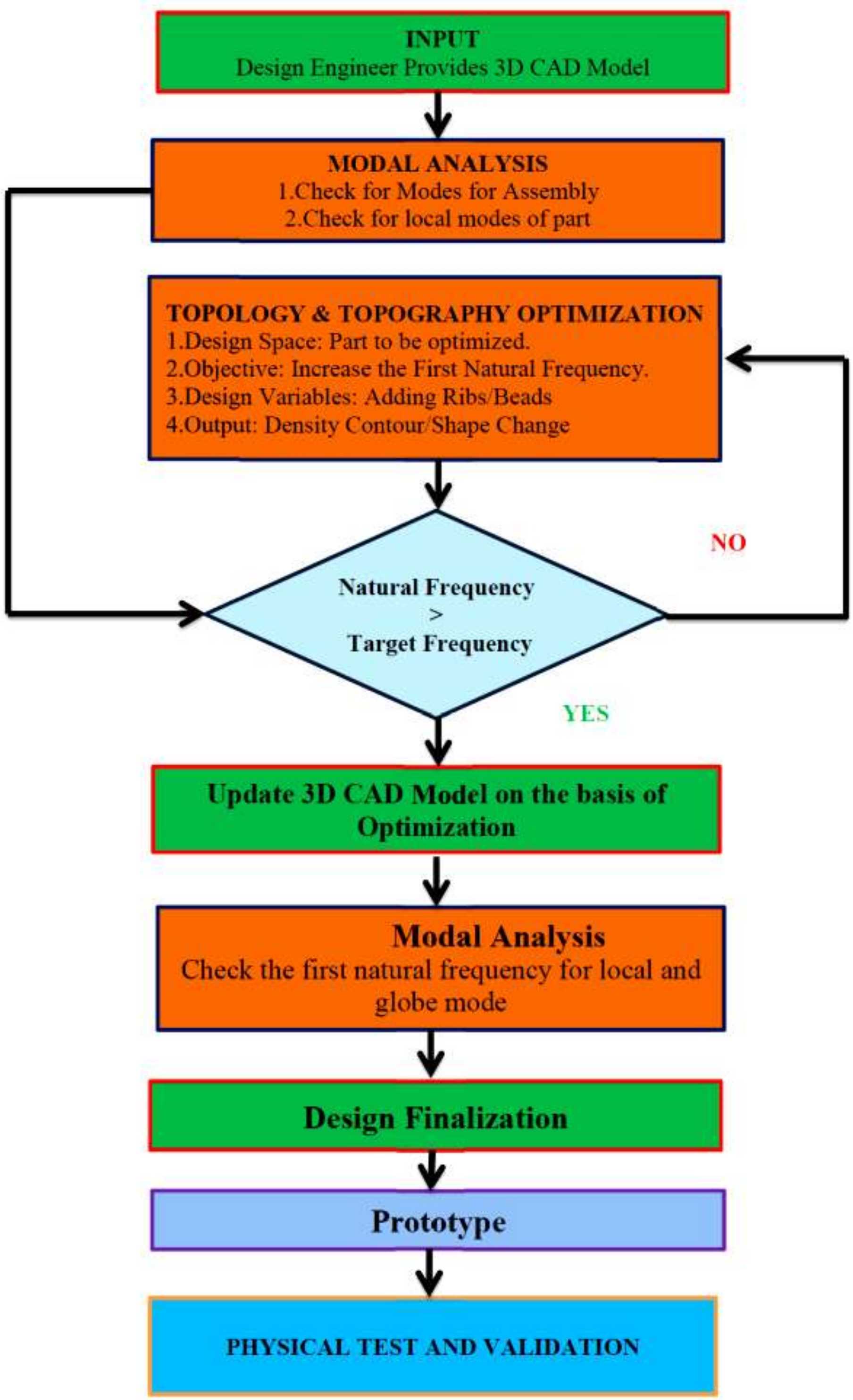

Fig. 1.2 Optimization Process Flowchart

1. Meshing of all the parts that have been designed by using the pre-processor HYPERMESH 12.0
2. NASTRAN is use as the solver for finding out the analysis result.
3. Finally the HYPERVIEW is use as a post processor.

4. Optimization of Topology to increase Natural Frequency
5. Correlation of FEA results with physical test results.

III NATURAL FREQUENCY ANALYSIS STUDY

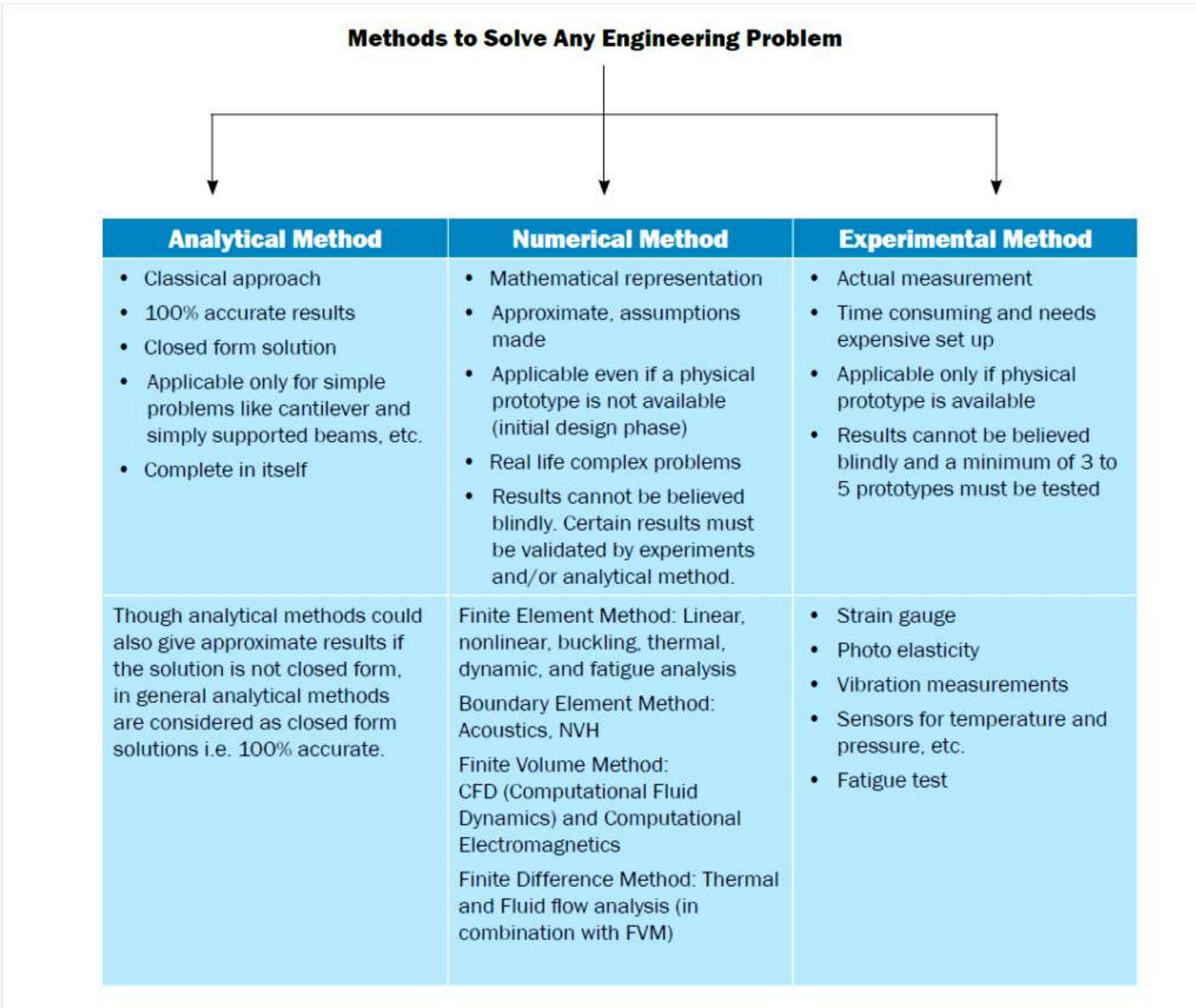

Fig.1.3 Different Methods to solve Engineering Problem.[3]

The "CAE-Driven Design Process" has gained significant attraction in most industries such as aerospace, automotive, biomedical, consumer goods, defense, energy, electronics, heavy industry, and marine throughout the last years. There are many reasons for the overall acceptance of CAE as simulation has proven to help when finding:

- New and inspiring designs.
- Products with better quality. (e.g. increased material efficiency where less material = lighter designs)
- Designs faster (i.e. due to shortened development cycles and a reduction in the number of prototypes by minimizing "Trial and Error" attempts.[3]

In other words, simulation saves time, reduces costs, and essentially strengthens the competitiveness of companies, thus strengthening their market position. When doing an analysis, we always target optimum designs, but the methods and tools we use in achieving the optimum design makes a difference. Still, in many places the design process is a trial-and-error process which depends on the selection of the initial design. This is not a well and established process in terms of how the

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design evolves and depends on the engineer's prior experience. Due to these challenges reaching the best design is not guaranteed.

To overcome these hurdles, numerical optimization is used to search for and determine the optimum design.
The term CAE (Computer Aided Engineering) includes the following types of analyses:

1) Linear static analysis
2) Nonlinear analysis
3) Dynamic analysis
4) Buckling analysis
5) Thermal analysis
6) Fatigue analysis
7) Optimization
8) CFD analysis
9) Crash analysis
10) NVH analysis

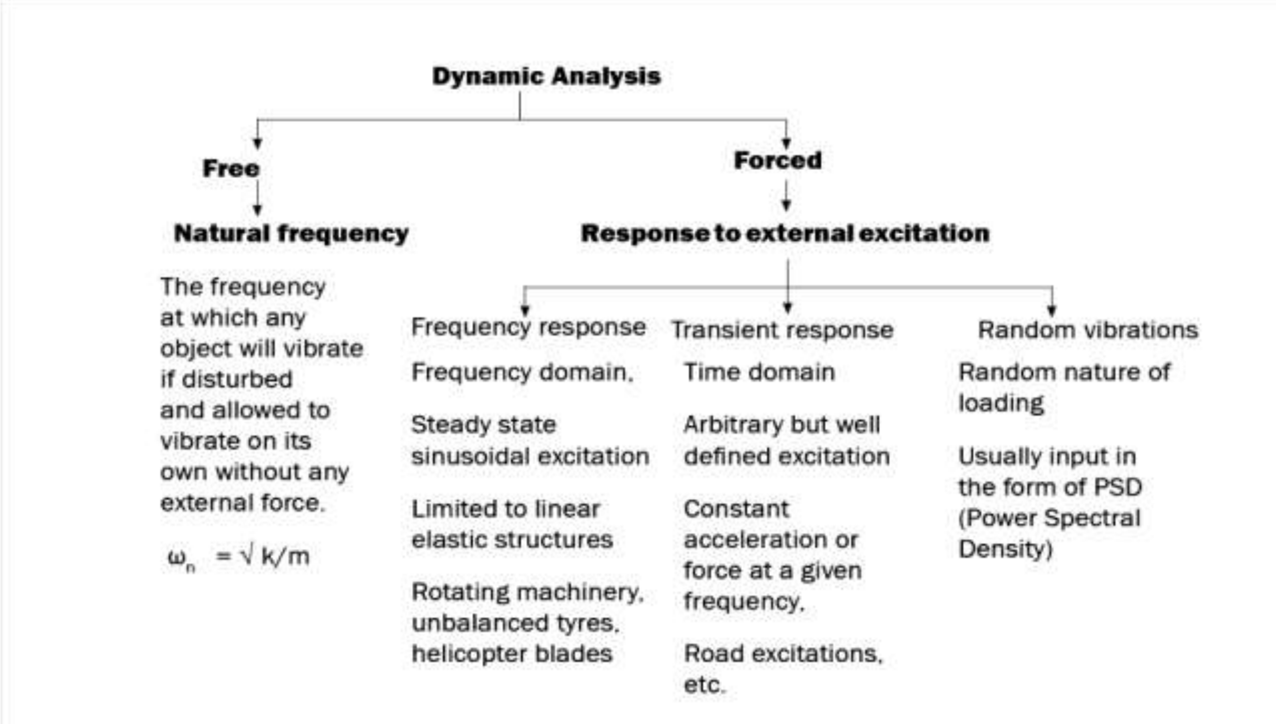

Fig. 1.4 Types of Structural Dynamic Analysis.[3]

Frequency response analysis is used to calculate the response of a structure about steady state oscillatory excitation. Typical applications are noise, vibration and harshness (NVH) analysis of vehicles, rotating machinery, and transmissions. Frequency response analysis is used to compute the response of the structure, which is actually transient, in a static frequency domain. The loading is sinusoidal. A simple case is a load of given amplitude at a specified frequency. The response occurs at the same frequency, and damping would lead to a phase shift. The loads can be forces, displacements, velocity, and acceleration. They are dependent on the excitation frequency. The results from a frequency response analysis are displacements, velocities, accelerations, forces, stresses, and strains. The responses are usually complex numbers that are either given as magnitude and phase angle or as real and imaginary part.

IV FEA SOFTWARES

Table 1.1 FEA Software Packages

Type of FEA software	Examples
Preprocessing	Hypermesh, ANSA, Patran, etc.
Solver	Nastran, Ansys, Optistruct, LS-DYNA , RADIOSS, Acu solve, Motion solve, etc.
Post processing	Hyperview, Hypergraph, Abaqus viewer, Patran, etc.

V ADVANTAGES OF FEA

- Visualization ↑
- Design cycle time ↓
- No. of prototypes ↓
- Testing iterations ↓
- Optimum design [3]

VI BENEFITS OF OPTIMIZATION AND NVH ANALYSIS

Cost is a driving force in today's competitive market. Automotive suppliers face persistent cost pressure from the OEMs due to fierce market competition. This competitive environment requires automotive manufacturer to utilize advanced technology to identify and implement cost saving opportunities with CAE solutions being among the most effective. Using different material, a cost savings will be achieved but the NVH performance of the Instrument Cluster will degraded. Topology optimization is a mathematical technique that gives optimum material distribution within defined design space envelope. This method normally deals with maximizing the stiffness (minimizing the compliance) approach. With effective utilization of Optimization, Rib optimal addition can be made, which lead to more cost effective than material change. The design and optimization are iterative processes. Hence, with the conventional methodology the productivity as well as accuracy of the results is compromised with the improved methodology discussed above, found to be more successful in the cycle of instrument cluster design and optimization. [2]

CONCLUSION

Instrument Cluster using Topology optimization techniques which are used in the concept level of the design process to arrive at a conceptual design proposal that is then fine-tuned for performance and manufacturability, demonstrate an innovative way of solving real-world engineering problems. The proposed design not only shows the cost advantage over the original design but also provide better NVH performance for the entire system. This is evidence of the potential benefit of design optimization for future products with similar applications. The proposed optimization approach helps to resolve the issue in a timely manner. The optimization applications attempts to share innovative ways of improving product design and inspire more use of optimization applications in industrial communities.

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