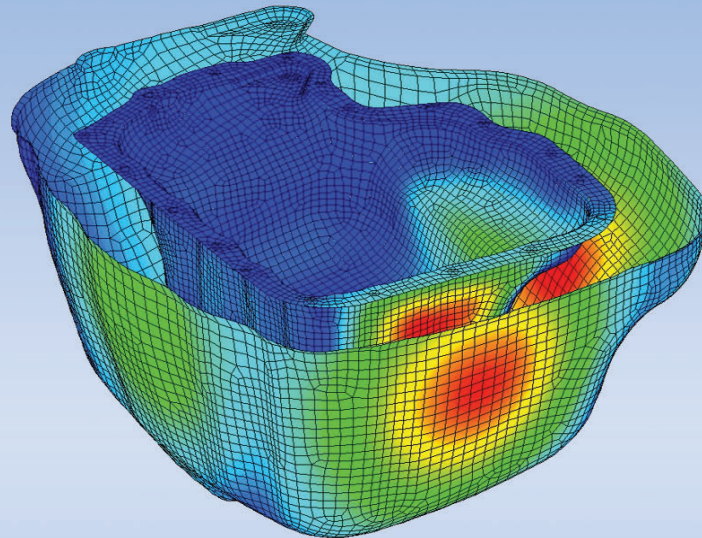


NVH – Vibration/Acoustics

Simulation and Testing



Computed surface velocity and sound pressure of an oilpan

Noise Vibration Harshness (NVH) at IAV

Powertrain and vehicle acoustics and vibrations are becoming a major focus of modern car development. Customer expectations drive the development goals. By providing simulation and testing to our customers, IAV supports them in achieving their tough quality targets – on ever tighter schedules.

Vehicle Testing

The acoustic quality of a vehicle is directly experienced by the customers and plays an important role when it comes to judging the comfort of a car. IAV utilizes specialized testing equipment and techniques to reduce unwanted noise and vibration and to achieve a desired sound.

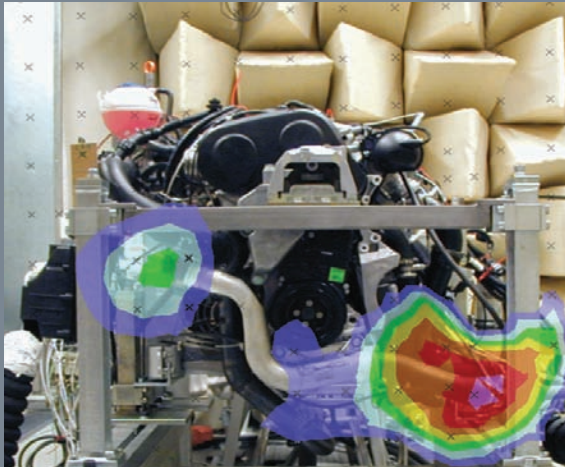
The dynamic properties of the chassis also influence ride comfort, drivability, and safety. The interior and exterior sound radiation and the vibration can be measured on an IAV-test track.

Typical Vehicle Tests

- ▶ Measurement of noise emitted by accelerating road vehicles (ISO 362)
- ▶ Noise emission from the stationary vehicle and outlet noises to ECE-R 5
- ▶ Artificial head recordings for psychoacoustic evaluation (e. g. loudness, harshness)
- ▶ Interior acoustics, sound pressure
- ▶ Ride comfort analysis, benchmarking
- ▶ Idle testing
- ▶ Stiffness BIW, operating deflection shapes
- ▶ Laser vibrometry



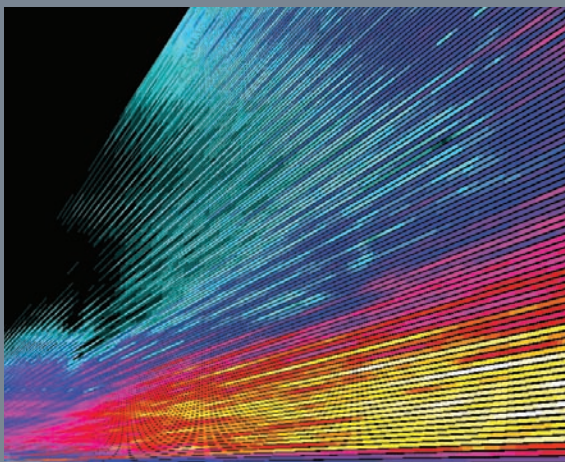
Mobile artificial head measurements for psychoacoustic evaluation



Source localization via intensity distribution



Measurement of the surface velocity by laser vibrometry



Computed sound emission while engine speed is being revved up

Powertrain Testing

After minimizing vibration as well as direct and indirect noise emissions of the internal combustion engine, sound design becomes the area where real customer benefits can be achieved.

For NVH investigations of the powertrain, engineers at IAV use up-to-date measurement equipment, among others: acoustic powertrain test bench, mobile multi-channel measurement systems, artificial heads for psychoacoustic analyses, laser-vibrometry, and testing robots for repeatable testing.

Typical Powertrain Tests

- ▶ Sound emission measurement
- ▶ Locating and analyzing sound sources
- ▶ Psychoacoustics
- ▶ Sound design
- ▶ Analyses of operating vibration forms
- ▶ Experimental modal analysis
- ▶ Vibration measurements
- ▶ Signal analysis/knock control

Computation/Simulation

Numerically analyzing and optimizing the dynamic and acoustic behavior of the powertrain and overall vehicle is a focal aspect of IAV's computation and simulation activities. It is an integral part of the NVH development process at IAV.

Supported by an extensive NVH database, computation and simulation play a key part in optimizing solutions for our clients throughout the course of development from the idea to mass production.

Doing so, our developers not only compute, simulate and evaluate vibrational behavior at points relevant to comfort but also the sound that is emitted into the passenger compartment and on the outside of the vehicle. Computation results can be made audible at the computer for psychoacoustic assessment.

IAV's developers apply modern methods of computation and simulation, e. g. FEM, MBS, BEM and CFD, using powerful and efficient software and hardware.

Employing mathematical optimization procedures to enhance dynamic and acoustic properties, proposed solutions are then efficiently integrated in the development process.

As such, computation and simulation are instrumental in providing vehicles with the comfort and acoustic qualities that consumers want.

Typical Simulations

- | | |
|--|-------------------------------|
| ▶ Numerical modal analysis | ▶ Transfer path analysis |
| ▶ Frequency and time response analysis | ▶ Structure-borne sound power |
| ▶ Durability | ▶ Airborne sound power |
| ▶ Fatigue strength | ▶ Psychoacoustics |
| ▶ Engine mounting optimization | ▶ Sound design |
| | ▶ Optimization |