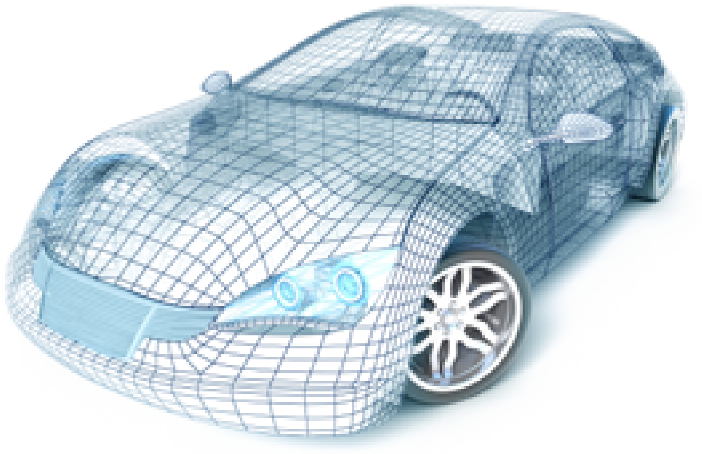
Energy-based FEM

Novicos' EFEM software enables efficient simulations in higher frequency range

Harmonizing lightweight concepts with NVH (noise, vibration and harshness) poses a real challenge for automotive manufac-tu-rers. Compared to classic designs, vibrations caused by cer-tain components (e.g. motor vibrations) are being transmitted more easily onto the lighter structure - and thus have a higher impact on the car's vibro-acoustic behavior.

In order to adjust designs early on and keep development costs low it is essential to identify and evaluate noise and vibration phenomena at an early stage. Numerical methods like Finite Element Method (FEM) or Boundary Element Method (BEM) reach their limit in the higher frequency range, especially with larger and more complex technical systems. As a result, simula-tion becomes inefficient.



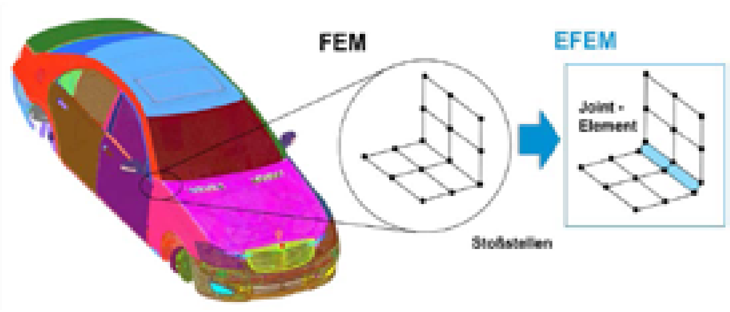
Energy-based Finite Element Method (EFEM) enables you to examine even large structures in a higher frequency range (depending on mode density).

How does EFEM work?

While conventional FEM is based on displacements EFEM is based on time and location averaged energy densities. The underlying energy equations are set up based on elements similar to FEM.

As these elements are much smaller than elements in other energy-based methods, e.g. Statistical Energy Analysis (SEA), they allow finer modelling as well as a detailed structural analysis by taking into account local effects. Due to the energy-based approach EFEM operates at a lower discretization level than FEM/BEM, which reduces computation time and memory requirements.

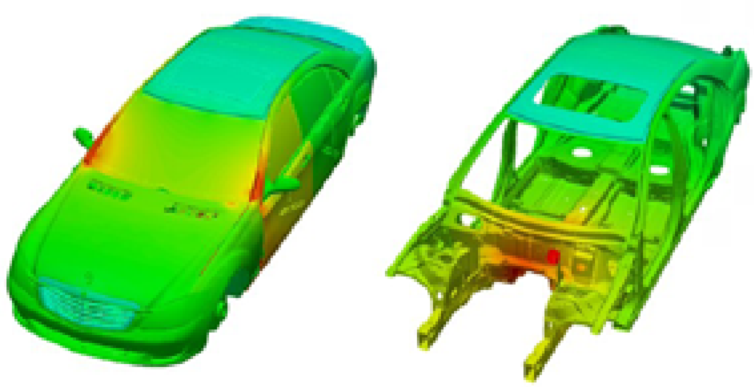
Novicos developed a simulation routine for EFEM and EBEM, which requires only minimal input from the user. To execute an EFEM simulation an existing FEM model can be used (i.e. one you would use for calculations in the lower frequency range). Energy transfer needs to be considered particu-larly at joints, e.g. places where flat components meet at a certain angle. These are automatically recognized during import of the data by the systems'



pre-processor. For specifying the transfer of the oscillation energy at these joints via transmission coefficients joint elements are added at these points (Fig. 1). This whole procedure takes place in the pre-processor and especially takes into account the car's numerous welding points.

User Inputs and Final Result

The user now needs to define input power at the excitation points. The absorption coefficient of sound-absorbing surfaces can act as a boundary condition. The calculation is solved via the unknown energy densities at the joints, so you get the energy density distri-bution on the structure and in the fluid as a result (Fig. 2). On flat surfaces bending shaft, shear and longitudinal wave are distinguished, especially at the joints. The calculated energy den-sities help determine the vibration and sound pressure levels even at higher frequencies as well as identify components with special relevance to sound pressure levels in the cabin.



For efficiently simulating radiation you can use Energy-based Boundary Element Method (EBEM), which is also implemented in the code. Similar to conventional BEM only the surfaces of the emitting object are discretized, so the application is much more efficient when it comes to large fluid areas. For instance, when simulating pass-by noise of a car in a higher frequency range.

EFEM has been verified respectively validated for a number of components, such as vibration characteristics of a lightweight cross beam and the energy transmission onto a gear box with a fluid gap. Furthermore, EFEM functionality for calculating trans-mission functions can be used in combination with Fraunhofer's AdaptroSim toolbox.

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