Simulation of Acoustical Transfer Paths for Active Noise Control

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Abstract

Today working with loud machines of any kind is an issue of occupational safety. Passive damping is mostly found in common use for noise protection. Earmuffs or cabins for the operator or the machine itself reduce the sound by using sound-absorbing material. Unfortunately, the passive noise control does not work well for low frequencies. Contrary active noise control (ANC) is sound reduction using a power source. An ANC-system analyses the noise and generates contrariwise sound, i.e. a noise-cancellation speaker emits sound with the same amplitude but inverted phase to the original sound wave so that destructive interference is created and the original noise is reduced significantly (see Fig. 1).

Due to the three-dimensional wave-like propagation of sound in fluids like air, this cancellation effect is restricted to small areas. It depends on the frequencies, the position of the noise-source and the position of the speaker(s) that emit the "anti-noise" as well as the geometry of the surrounding area (e.g. a room, a cabin or a free field). For the development of ANC-systems using model-based engineering it is important to reproduce conditions of the real world situation in a model. To analyze the transfer paths in given geometries acoustics simulations were performed.
For model verification a measuring setup was created to get data of the real system. A tube made of PMMA (polymethyl methacrylate) was assembled with a speaker at one front side and a microphone at the other side. The length of the tube was adjustable by moving the front side back and forth. For different lengths the system was stimulated by the speaker with frequencies from 1 Hz to 5000 Hz while the sound pressure level (SPL) was measured by the microphone at the other side of the tube. The corresponding model was built in COMSOL Multiphysics software by creating the tube as a solid body filled with air and using the sound hard boundary conditions for the surfaces. The speaker was modeled in a few different ways to analyze its effect on the SPL. The simulation results were compared to the measured data.

As shown in Fig. 2 modeling the sound source in detail, i.e. including the shape of the membrane of the speaker and its inward acceleration, generates results that are in good agreement with the measured data. In future projects more complex geometries will be analyzed. First tests with a harvester-cabin showed that interior parts like seats cause damping effects that are not negligible. To model the influence of the soft absorbing surfaces on the sound propagation in the cabin different impedance conditions can be used.

Figures used in the abstract

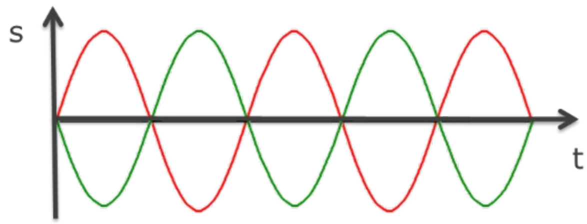

Figure 1: Active Noise Cancellation

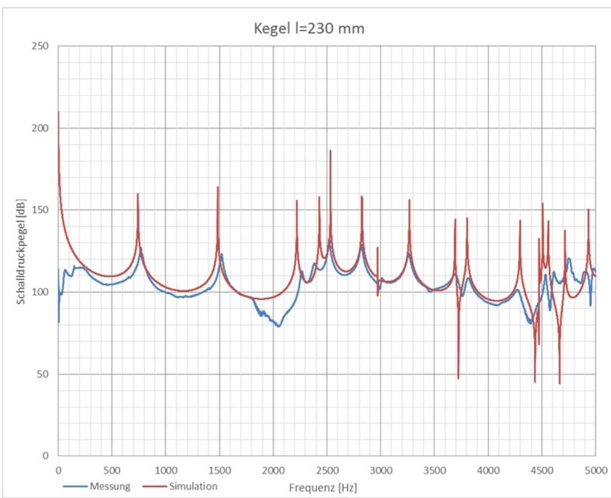

Figure 2: Comparison between numerical results (red line) and measured data (blue line)

Figure 3

Figure 4