Acoustic Imaging

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Introduction

Increasingly stricter government regulations and customer demands require silent products. As a consequence, manufacturers need to be able to predict and validate the sound field generated by their products to comply with legislation and customer requirements.

Objective

Development of a combination of efficient measurement techniques and numerical algorithms to predict sound fields and source distributions. The measurements will be performed with a novel acoustic velocity sensor, the microflown (*Figure 1*).

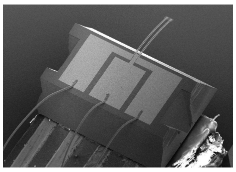

Figure 1 : Microflown (≈2x2 mm).

The algorithms use these measurements to calculate images of the sound field surrounding the product (acoustic imaging). With this knowledge, modifications to the original product can be made to reduce the radiated acoustic power.

Methods

When the surface vibrations of an acoustic source are known, it is possible to determine the sound field by direct evaluation of the Kirchhoff-Helmholtz integral (see also *Figure 2*):

$$p(\vec{r}_f) = \int_S j\omega\rho_0 v_n(\vec{r}_s) G(\vec{R}) - p(\vec{r}_s) \frac{\partial G(\vec{R})}{\partial n} dS(\vec{r}_s).$$

In general however the surface vibrations of the source are unknown and inverse source identification based on acoustic measurements is needed. These inverse methods require recording of the sound field on a measurement grid close to the surface of the acoustic source (*Figure 2*). From these measurements the total sound field and normal velocity distribution at the source surface can be reconstructed. Current research is focused on the application of two methods: nearfield acoustic holography (NAH) and inverse frequency response function methods (IFRF). Both reconstruction procedures tend to be highly ill-conditioned and regularization methods are necessary to obtain a physically meaningful solution.

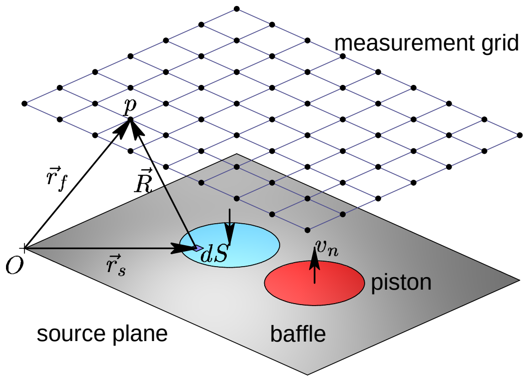

Figure 2 : Measurement setup of two vibrating pistons.

Results

We consider the reconstruction of two baffled pistons vibrating in anti-phase at 2000 Hz (see *Figure 2 & 3*). From the pressure on the measurement grid (black dots), the total pressure, velocity and intensity field have successfully been reconstructed with the holographic method.

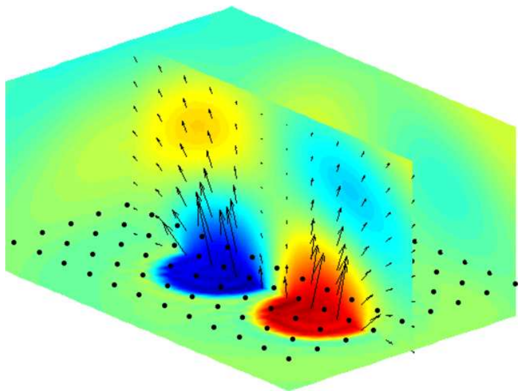

Figure 3 : Reconstruction of the normal velocity (contour) and mean intensity field (vector).

Future developments

- Development of novel multilevel methods to efficiently solve the integral equation.
- Reconstruction of the sound field of arbitrary shaped acoustic sources.

References

1. Williams, E.G. (1999) Fourier Acoustics, Washington D.C., Academic Press.