Title: Modelling of acoustic viscothermal losses using the Boundary Element Method: From method to optimization

Abstract:

Computer-based simulation and optimization tools can provide engineers with valuable insight into the behaviour of acoustic devices. These tools can also reduce the need for expensive prototypes, which are often rebuilt in multiple iterations of manufacturing and experimental validation.

Microphones and loudspeakers are acoustic transducers. The general trend is to reduce their size as much as possible so they can fit inside, for example, smartphones and hearing aids. As the size is reduced, sound waves inside such devices are modified in their propagation by acoustic losses, which are explained by the viscosity of air and the heat exchange with the device material. Including these effects into simulations with traditional methods comes at a significant computational cost, which in turn makes simulation and optimization of these small devices very challenging.

The Boundary Element Method (BEM) and the more extended Finite Element Method (FEM) are numerical tools that allow the study of physical setups through computer models. Both methods have the possibility of including acoustic losses, at the cost of a higher computational load. The BEM with acoustic losses can be advantageous in some particularly demanding cases, but it has some potential shortcomings that can lead to undesirable inaccuracies.

This PhD project investigates and improves on the existing BEM with acoustic losses by using two new mathematical coupling strategies that circumvent the mentioned weakness of the method. The new coupling strategies are evaluated and tested through several test cases, showing increased stability and reduced errors.

Based on this improved BEM, a shape optimization technique is developed. In shape optimization, the computer calculates and progressively modifies an acoustic setup, following a set of criteria previously defined by the user. The new shape optimization technique using BEM with acoustic losses is among the first to include acoustic viscous and thermal effects in the optimization process. It has a potential for the efficient design and improvement small acoustic devices, which is demonstrated in this PhD project using several examples.