Modeling a hearing aid loudspeaker

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Introduction

Hearing aid loudspeakers are very small and the trend is towards further miniaturization. Because of their small size, viscothermal effects are not negligible and standard acoustic models cannot be used to describe the air motion inside them. The objective of this research is to develop design tools for optimizing loudspeakers for hearing aids, mobile telephones and personal audio.

FEM model

A hearing aid loudspeaker contains several parts with complex geometries. Therefore, a flexible tool like FEM is needed to accurately model them. A 2D finite element for viscothermal wave propagation has been developed; see also [1]. It is based on the linearized Navier Stokes equations. The element accounts for the effects of:

- compressibility,
- inertia,
- viscosity,
- thermal conductivity.

The element was implemented in the finite element package Comsol.

Application example

Figure 1 shows a cross section of a common hearing aid loudspeaker with a balanced armature motor. An electrical signal powers the motor which drives the membrane. The air above the moving membrane flows to and from the spout through an opening in the casing of the loudspeaker. A tube can be attached to the spout to guide the air, and thus sound, to the ear canal.

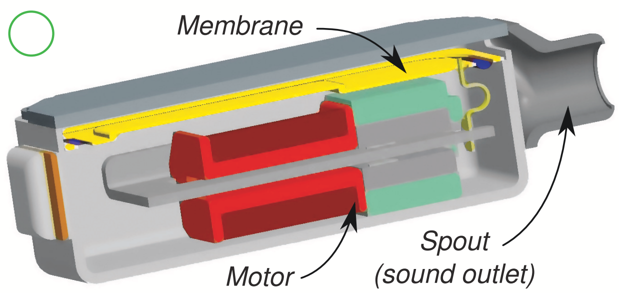

Figure 1 : Cross section of a hearing aid loudspeaker

A two-dimensional version of the spout of a hearing aid loudspeaker is modeled with the viscothermal element. It measures approximately 2 x 3 mm. The input is a harmonic uniform velocity source of 250 Hz. At the output, a normal flow and zero pressure condition is used. The remaining boundaries are modeled as isothermal and zero slip.

Figure 2 shows the velocity that results from the finite element analysis. The figure clearly shows the viscous boundary layer at the output. This boundary layer becomes smaller as the frequency increases.

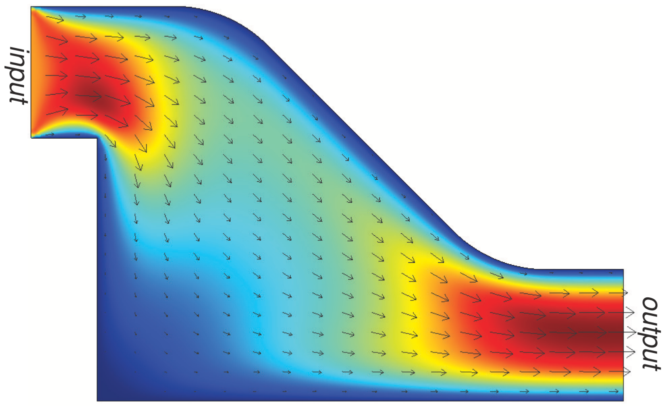

Figure 2 : Particle velocity in a 2D spout (real value)

Future research

Future research will be focussed on:

- developing a 3D viscothermal element,
- modeling fluid structure interaction,
- using the FEM model to asses various hearing aid loudspeaker designs.

Acknowledgements

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Reference

1. M. J. J. Nijhof, Y. H. Wijnant, A. de Boer (2006) An Acoustic Finite Element Including Viscothermal Effects, ICSV14, Cairns, Australia.

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