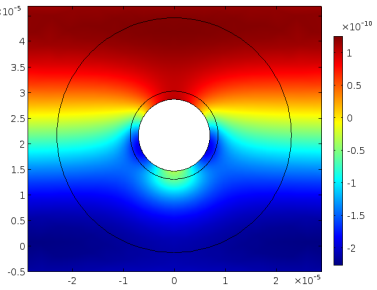
Lehrstuhl für Akustik mobiler Systeme
Department of Engineering Physics and Computation
Technische Universität München

Semester-, Masterthesis

Element Resolution Requirements for Thermoviscous Acoustics Finite Element Simulations

Topic



Thermoviscous acoustic models are essential for accurately predicting sound propagation and dissipation in narrow structures such as acoustic metamaterials, micro-perforated panels, and impedance tube samples. In contrast to classical pressure acoustics, thermoviscous formulations explicitly resolve viscous and thermal boundary layers at solid walls. As a result, numerical simulations require significantly finer spatial discretization near boundaries. In computational acoustics, a common rule of thumb suggests using approximately six elements per wavelength for linear time-harmonic pressure acoustics. However, it is unclear whether such guidelines remain valid for thermoviscous acoustics, where additional physical length scales such as viscous and thermal boundary layer thicknesses must be resolved.

This thesis aims to systematically investigate discretization requirements for thermoviscous acoustic simulations using the finite element method (FEM). Different element types, interpolation orders, and mesh resolutions will be evaluated with respect to accuracy and computational cost. Numerical results will be compared with analytical solutions for canonical benchmark problems, such as wave propagation in narrow ducts. Based on the analysis, guidelines for appropriate mesh design in thermoviscous acoustic simulations will be derived.

Tasks

- Literature review on thermoviscous acoustics and numerical discretization strategies.
- Study of viscous and thermal boundary layers and effects.
- Implement and perform finite element simulations of thermoviscous acoustic benchmark problems
- Investigate the influence of mesh resolution, element type, and interpolation order on numerical accuracy.
- Compare numerical results with available analytical solutions.
- Evaluate error measures and determine discretization requirements for reliable simulations.
- Derive recommendations for mesh design in thermoviscous acoustic FEM simulations.

Requirements

- Background in acoustics, mechanical engineering, physics, or related fields.
- Interest in numerical simulation and computational acoustics.
- Good knowledge of finite element methods.
- Programming or simulation experience (e.g., MATLAB, Python, COMSOL, or similar).

Contact

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