Convected Acoustic Physics Interfaces For Acoustic Resonance Technology

Antonio Jimenez Garcia[1], Elisabetta Merico[1]

[1]FT Technologies Ltd

Abstract

Acoustic Resonance (Acu-Res®) Technology [1] is at the core of FT wind sensors, operating by measuring phase shifts between a pair of transducers caused by fluid flow within an acoustic resonator. Three piezoelectric transducers are placed in a triangular formation on the top reflector of the resonating cavity, as shown in Figure 1, and they are excited one at a time to create a standing wave perpendicular to the direction of the fluid flow. On the other hand, the flow passing through the cavity induces a travelling wave, which in turn leads to a phase shift between paired transducers. This allows to compute the velocity modulus of the fluid flow along three axes, providing wind speed and direction.

Due to the inherent nature of the technology, the coupling between acoustics and aerothermal fields plays an important role. Previous work published by the Multiphysics Research Team at FT Technology has established numerical frameworks for accurately resolving the acoustic field of FT wind sensors in the absence of flow [2] and has extended these capabilities using machine learning algorithms to reduce computational costs while maintaining high accuracy and reliability [3]. This paper aims to establish a modelling framework for convected acoustics using COMSOL Multiphysics® [4], with a focus on applications in Acoustic Resonance Technology, through the evaluation of different physics interfaces to find the best compromise between accuracy and computational cost.

A review of the convected acoustic physics formulations available in COMSOL Multiphysics® [4] is first presented. The sensitivity of the solution to changes in the mesh density and computational domain's size and boundaries using the Perfectly Matched Layer (PML) and Acoustics Impedance techniques is explored. Subsequently, the influence of direct and iterative solvers on CPU and memory usage is investigated.

Finally, the effects of different background flow conditions will be considered to evaluate the limitations of the Linearised Potential Flow (LPF) model for convected acoustics propagation in ideal, irrotational potential flows, and to compare it with more advanced formulations such as the Linearised Navier-Stokes (LNS) model.

This work is part of FT Technologies' ongoing effort to continuously improve the Acu-Res® technology, as it will serve as a platform for an enhanced design lifecycle relying on SciML-based techniques.

Reference

[1] S. Kapartis "Anemometer employing standing wave normal to fluid flow and travelling wave normal to standing wave." U.S. Patent No. 5,877,416. 2 Mar. 1999
[2] A. Jimenez-Garcia and G. C. Diwan, "A comparison of acoustic solvers for FT ultrasonic wind," in 54th Spanish Congress on Acoustics, Cuenca, 2023
[3] E. Merico and A. Jimenez-Garcia, "Towards Machine Learning for Acoustic Resonance Technology", in COMSOL Conference, Florence, 2024
[4] COMSOL Multiphysics® v. 6.3. www.comsol.com. COMSOL AB, Stockholm, Sweden.

Figures used in the abstract

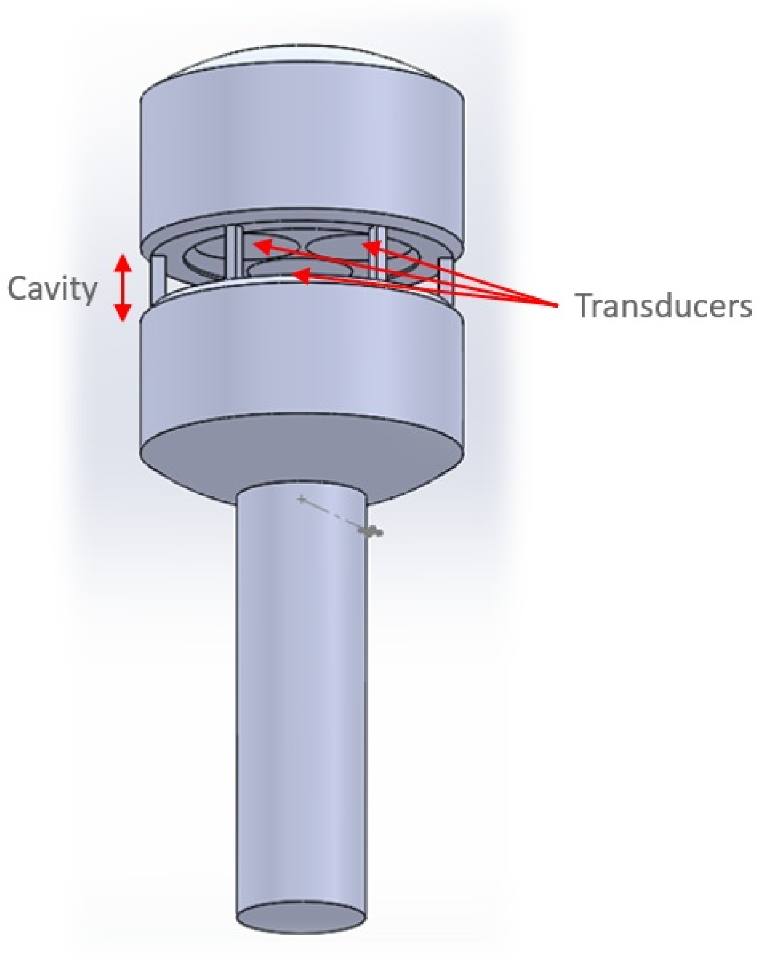

Figure 1 : Wind sensor’s simplified geometry, taken from reference [3]