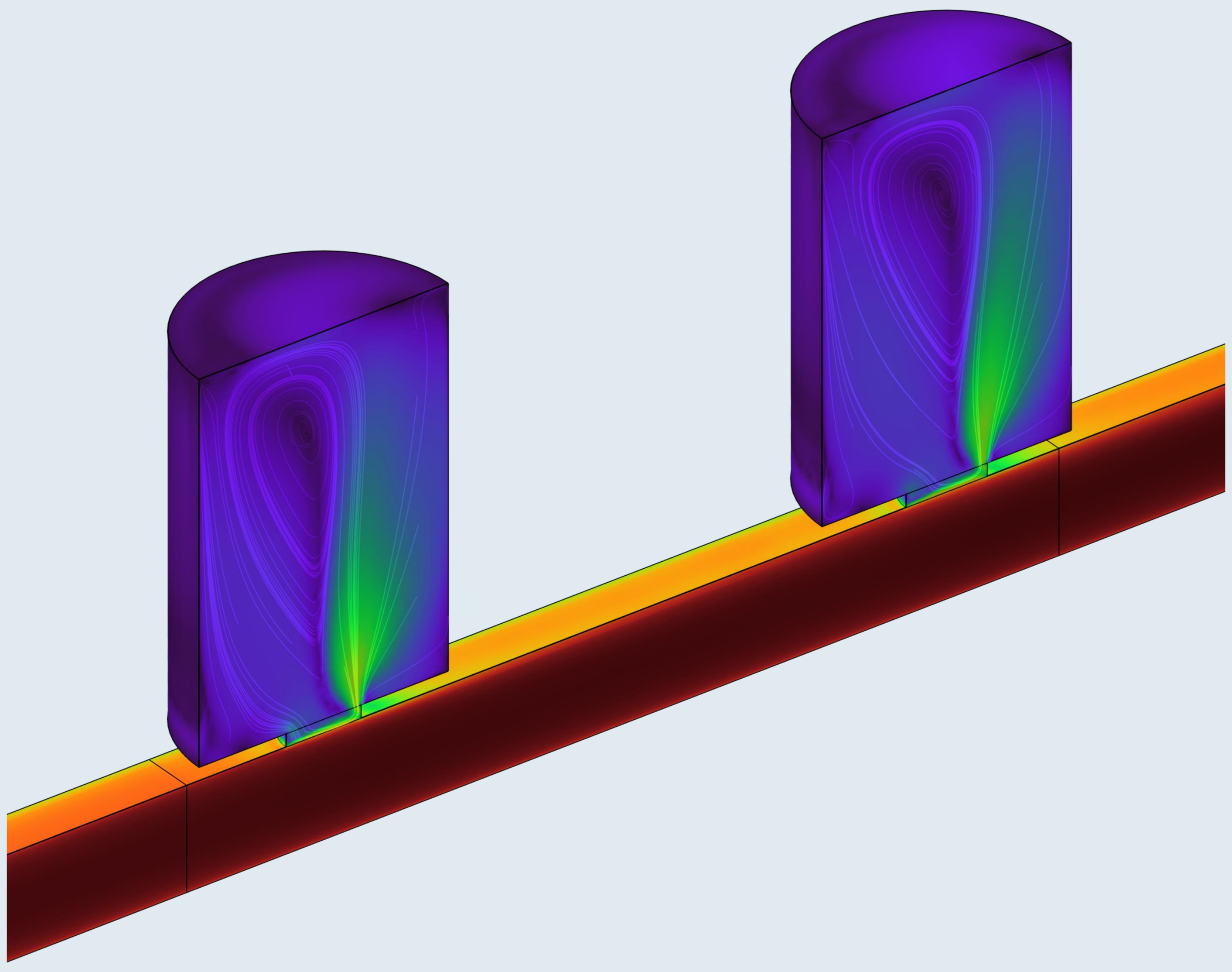

A Comparative Analysis Of Transmission Loss In Helmholtz Resonators And Quarter Wave Resonators

Helmholtz resonators and Quarter-wave resonators are used to attenuate noises. In the presence of background flow, the performance of resonators is studied through numerical simulation.

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Abstract

This study involves a comparative analysis focusing on the transmission loss (TL) exhibited by both the Helmholtz resonator (HR) and the quarter-wavelength resonator (QWR). Employing both analytical and numerical approaches, we predict and assess the HR and QWR performance. In this investigation, the HRs and QWRs are integrated as side branches to a main duct. Furthermore, we explore the influence of mean background flow on the transmission loss of these resonators. FEM-based COMSOL Multiphysics is used for numerical simulation using the Acoustic Module and the CFD Module.

Utilizing the numerical model makes it feasible to maximize the extent of noise reduction via optimal design. Consequently, this approach effectively minimizes the cost and time required for construction and experimentation.

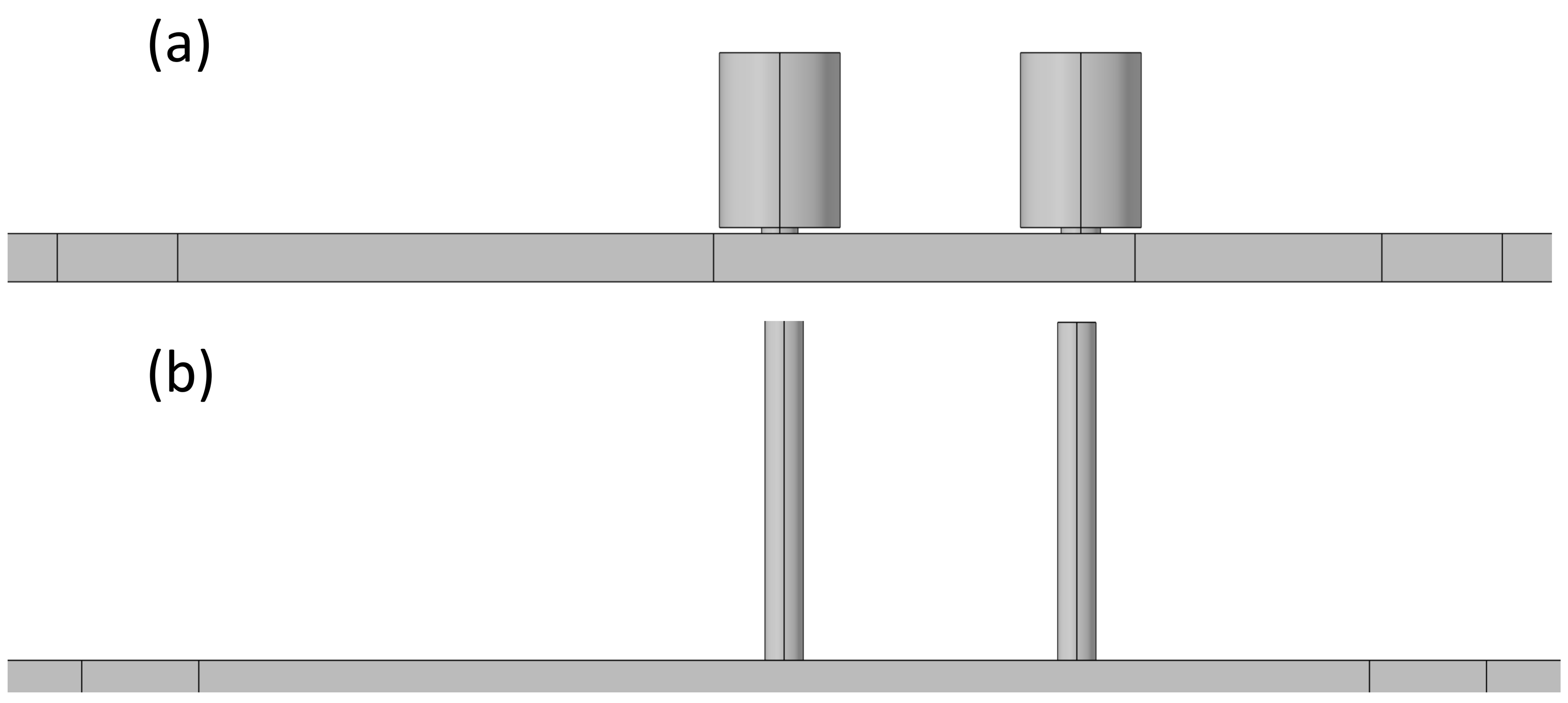

Figure 1: Two-type resonators (a) Helmholtz Resonators, and (b) Quarter wavelength resonators.

Methodology

The geometry of the proposed structures is shown in Figure 1. The geometry consists of a main rectangular duct with a cross-sectional area of 64 cm^2. Two different HRs with fixed cavity volume, neck length L= 1 cm, but different neck cross-section area r1= 3 cm, and r2 = 3.2 cm, respectively, and (b) Two different QWRs with fixed cross-sectional area (r = 3 cm), but different length L1= 58 cm, and L2 =55 cm, respectively connected to the side of the main duct.

The plain acoustic wave, added as a background acoustic field enters the system downstream. The transmission loss of the system is defined as: $TL = 20\log_{10}\left(\left|\frac{1\,Pa}{P_{out}}\right|\right)$, where P_{out} is the average pressure at the outlet.

Results

The results in Figure 2 show the transmission loss of the Helmholtz resonator and the Quarter wave resonator. The HR has a larger damping capacity compared with the QWR. Using multiple HRs or QWRs increases the transmission loss for a broad range of frequencies.

This Numerical study also investigates the impact of mean background flow within the system, which alters the acoustic properties of the resonators. The mean flow is calculated for Ma = 0.05 and Ma = 0.1. The QWRs show better damping behavior in the presence of background flow.

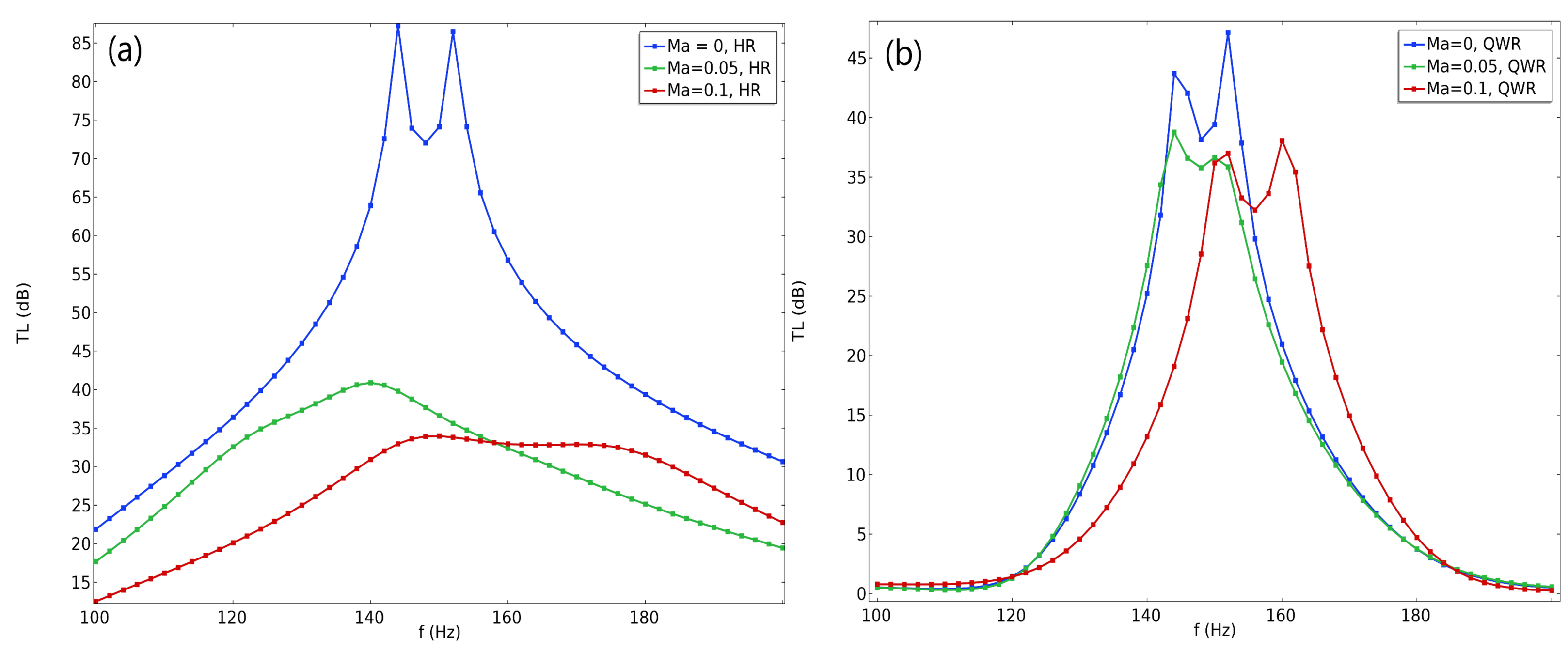

Figure 2: Transmission loss (dB) for three flow configurations. (a) Helmholtz Resonators. (b) Quarter wave resonators.

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