Elliptical side resonators for broadband noise reduction

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Introduction

Cooling fans are one of the main noise sources in computers. Previous research of the authors pointed out that side-resonators can be applied to reduce fan noise. It was found that the choice of the resonator geometry influences the broadband reduction capabilities, which is important when resonators are used for noise reduction of speed controlled fans.

Objective

In the present study, it is investigated to what extent elliptical resonators, consisting of an elliptically shaped air layer, can be used to achieve broadband noise reduction. To this end, a modular model consisting of multiple acoustic elements, that describe viscothermal wave propagation in ducts and side-resonators of various geometry, is extended with an elliptical element.

Methods

The elliptical acoustic element used in the modular model describes the relation between the average pressures and particle velocities at the resonator inlet and back wall (figure 1).

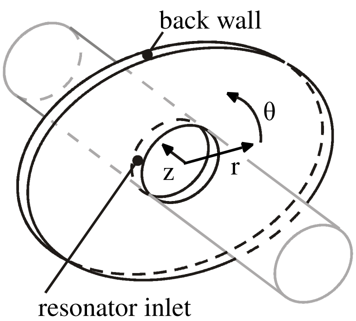

Fig.1) Elliptical side resonator mounted in a duct

To derive this relation, a semi-analytical model that describes the 2D wave propagation in the resonator is developed. The solution is derived from the set of equations that form the basis for the so-called Low Reduced Frequency model (LRF model). Separation of variables in cylindrical coordinates yields a solution consisting of an infinite number of sound fields.

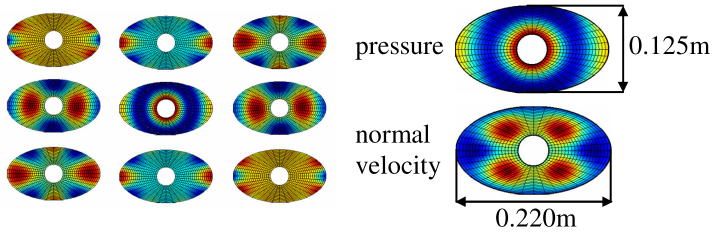

Fig.2) contributing pressure fields and total solutions for pressure and normal velocity at 3000Hz

The contribution of each field (figure 2) is found by disregarding higher order fields and applying boundary conditions either in an integrated sense using weighing functions or by means of collocation.

Experimental setup

An experimental setup was build to validate the developed model. The Insertion Loss (IL) of a resonator when it is mounted in a duct is measured and compared with the calculated Insertion Loss.

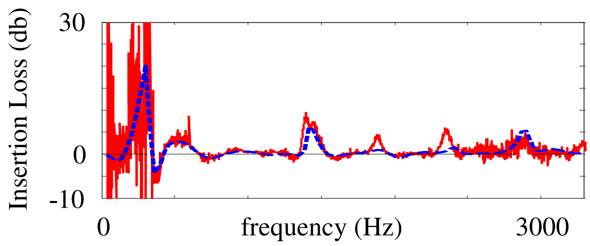

Fig.3) Calculated (– –) and measured (—) Insertion Loss

Results

The calculated and measured Insertion Loss match very well between 500 and 1500 Hz. Notice that for higher frequencies the location of the peaks are accurate but the calculated amplitude is too low.

Discussion

The system that has to be solved to obtain the contributions of the different fields is ill conditioned. Therefore, the contributions of only the most dominant fields can be calculated with enough accuracy. More research is needed to verify if representing the solution in a different coordinate system yields better results.