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Flow-sound interaction mechanisms during the resonance of trapped diametral modes in shallow cavities

The excitation of trapped acoustic modes within ducted cavities is often encountered in various components of nuclear and conventional power plants, jet engines, turbo-compressors and other engineering equipment. This phenomenon is investigated for a square shallow cavity during the resonance of its lowest four acoustic modes (Figure 1). The unsteady flow structure and the acoustic mode shapes during these resonances are detailed by means of pressure measurements at various azimuthal locations, time resolved particle image velocimetry technique, and numerical simulation of the resonant modes using finite element analysis. Three different interaction patterns are analyzed, corresponding to the resonance of a single stationary acoustic mode, simultaneous excitation of two different stationary acoustic modes, and a special case of spinning mode resonance due to the excitation of two degenerate acoustic modes. After reviewing the general resonance response of the four acoustic modes, attention will be focused on the dual resonance case (i.e., simultaneous excitation of modes 3 & 4 which have different frequencies and mode shapes). In this case, the circumference of the cavity shear layer is found to be divided into 8 segments, each of which is acoustically excited at a frequency which is different from those exciting the adjacent segments. The excitation level is also not uniform over each segment. Despite this rather complex pattern of acoustic excitation along the shear layer circumference at the upstream cavity corner, coherent vortices of different frequencies and phase do form over various segments of the shear layer circumference and are found to retain their individual coherence as they travel along the cavity mouth up to the downstream corner. The results of this study substantially improve our understanding of this complex excitation mechanism and the acquired flow visualization images constitute a challenging benchmark case for the validation of Computation Aero-Acoustic (CAA) codes.

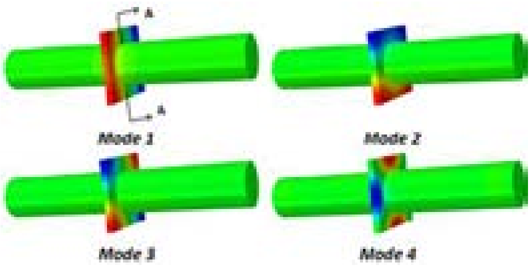

Figure1: *Acoustic pressure distributions of the first four trapped acoustic modes obtained by means of numerical simulation*

Biography

Samir Ziada is a Professor at McMaster University and former Chair of Mechanical Engineering. He had 17 years of industrial experience with Sulzer Innotec Ltd. in Switzerland, before joining McMaster University in Canada in 1998. He has received several awards, including the Premier Research Excellence Award of Ontario, the McMaster Award for Excellence in Undergraduate Teaching and the McMaster President Award for Excellence of Graduate Supervision. His research expertise is in the areas of industrial aeroacoustics, flow-induced vibration and unsteady flows. He is currently a regular consultant to several industrial institutions, including the US Nuclear Regulatory Commission, Argonne National Laboratory, Brookhaven National Laboratory, among others. He served as an Associate Editor for the *Journal of Fluids and Structures* and the *Journal of Pressure Vessel Technology*. He is a Fellow of the ASME and the CSME and has been the Chair of the ASME Technical Committee on Fluid-Structure-Interaction.

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