Orifice impedance under grazing flow measured with a single microphone method
Kooijman, G.; Golliard, J.; Hirschberg, A.

Published in:
Proceedings of the 10th AIAA/CEAS Aeroacoustics Conference, 10-12 May 2004, Manchester (UK)

Published: 01/01/2004

Document Version
Publisher’s PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:
• A submitted manuscript is the author’s version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher’s website.
• The final author version and the galley proof are versions of the publication after peer review.
• The final published version features the final layout of the paper including the volume, issue and page numbers.

Citation for published version (APA):
Orifice Impedance under Grazing Flow Measured with a Single Microphone Method

G. Kooijman*

Department of Applied Physics, Eindhoven University of Technology, The Netherlands

J. Golliard†

TNO-TPD, Delft, The Netherlands

A. Hirschberg‡

Engineering Fluid Dynamics Laboratory, University of Twente, Enschede, The Netherlands

The effect of one-sided grazing mean flow on the acoustical impedance of rectangular orifices is measured at low Mach number and low Helmholtz number by means of a single microphone method. The results are fairly consistent with previous experimental results obtained by means of a two-microphone impedance tube. Furthermore no significant influence of the aperture aspect ratio and aperture wall thickness on the non-dimensional scaled impedance is found, at least for the qualitative trend. Comparison with an existing theoretical model shows reasonable agreement for the resistance, provided that the experimental results are tentatively corrected for boundary layer- and induced flow effects. For the reactance no agreement is found.

I. Introduction

In order to suppress noise in ducts, such as combustion engine exhausts and in- and outlets of jet engines, acoustic damping material, protected by perforated plates, can be placed at the walls. Often the damping material itself is omitted, and the space between the perforate plates and the backing wall is filled with honeycomb structure. The so obtained acoustic liner is then basically an array of Helmholtz resonators, cf. figure 1. Sometimes one or two additional layers of resonators are used to obtain a double Degree Of Freedom (DOF) respectively triple DOF liner. The acoustic properties of a Helmholtz resonator are partly determined by the impedance of its orifice. Due to the specific application in liners, especially the effect of grazing flow on the orifice impedance is of interest. This has been investigated experimentally by several authors, e.g. Ronneberger, Goldman and Panton, Kirby and Cummings. These studies concern the impedance of circular apertures or perforated plates in duct flow for very low Strouhal numbers and thin or thick boundary layers. Generally, it is concluded that above a certain velocity limit the effect of the flow is to increase the resistance (absorption) and to decrease the reactance (added mass). Ronneberger proposed a simple model, which predicts the experimental results well, but is argued to be only valid for thin boundary layers and low Strouhal number. Goldman and Panton and Cummings give empirical formulas which solely predict absorption and no sound production by the orifices. Sound production was measured, but was assumed to be due to experimental error. Howe proposed a theoretical model for linear perturbations. For the specific case of a rectangular aperture with large aspect ratio an exact analytical expression was given for the orifice impedance. Strouhal number ranges for sound absorption as well as production are predicted. The theoretical model of Howe will be summarized in section II. Golliard experimentally investigated the impedance of a rectangular orifice with large aspect ratio. A two-microphone impedance tube was used. He compared his results with the theoretical model of Howe.

*PhD student, email: g.kooijman@tue.nl
†Senior researcher
‡Professor

American Institute of Aeronautics and Astronautics