29th International Congress on Sound and Vibration
The annual congress of the International Institute of Acoustics and Vibration (IIAV)
9–13 July 2023
ICSV29

AN INVESTIGATION OF PERFORATE REACTANCE UNDER HIGH LEVEL AND GRAZING FLOW EXCITATION

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Perforates are frequently used as part of sound reducing treatment in for instance aircraft engine and IC engine applications. In these applications they are exposed to fluid flow and high-level acoustic excitation, and this influences the acoustic properties of the perforate, as is well known from many published papers. The acoustic properties are usually described using a transfer impedance. In a previous part of this study the effect on the real part (resistance) of the transfer impedance was studied using both a conventional impedance tube (two-port) setup and an innovative three-port setup. The three-port configuration made it possible to study both the effect of grazing flow and high-level excitation effects separately as well as jointly. The present paper is a follow-up study where the imaginary part (reactance) of the transfer impedance is the focus. Comparisons are made with results from previously published papers and empirical models.

Keywords: aeroacoustics, perforates, effects of flow, nonlinear effects

1. Introduction

Investigations of the influence of grazing mean flow and high-level acoustic excitation on the acoustic properties of perforates has a long history, see e.g. [1]. In [2] it was found that the so-called impedance eduction techniques used to experimentally determine the impedance of aircraft engine liners give different results depending on if the main acoustic propagation direction coincides with, or is opposite to the mean flow direction. One idea with the three-port method used in the present study was to see if this effect can be found using a more direct way for obtaining the perforate impedance compared to the impedance eduction methods. The three-port measurement technique also made it possible to study the joint effect of grazing mean flow and high-level acoustic excitation. Comparisons were made with empirical models for the effect of grazing mean flow [3] and high-level acoustic excitation [4]. Results for the resistance of the acoustic transfer impedance of a perforate has been published in a previous paper [5]. The present paper is a follow up looking at the effect on the reactance, which can be expected to be smaller, but anyway of importance for accurate design of acoustic liners or mufflers.

2. Experimental technique

The three-port setup, which is described in [5], has a main duct divided into a section upstream in the grazing flow direction relative to the sample and a downstream section. The perforate sample is covering the rectangular opening of the side-branch section. In each of the three ducts there are loudspeakers and microphones making it possible to perform plane wave decomposition and to calculate the three-port scattering matrix. The perforate transfer impedance, defined as the acoustic pressure difference over the sample divided by the particle velocity through the sample, is determined from the scattering matrix.

3. Results

Figure 1 shows the difference between the imaginary part of the transfer impedance with and without flow, normalized by one standard end correction (0.85kd, where k is the wave number and d the hole diameter), as a function of Mach number. It can be seen that the reactance decreases by approximately one end correction as the Mach number increases. In Fig. 2 high-level acoustic excitation is added at one Mach number (0.044). The figure shows the change in reactance as a function of the ratio between rms-value of the acoustic particle velocity and the flow speed for different frequencies. It can be seen that there is a slight recovery (increase) of the reactance as the level of acoustic excitation is increased.

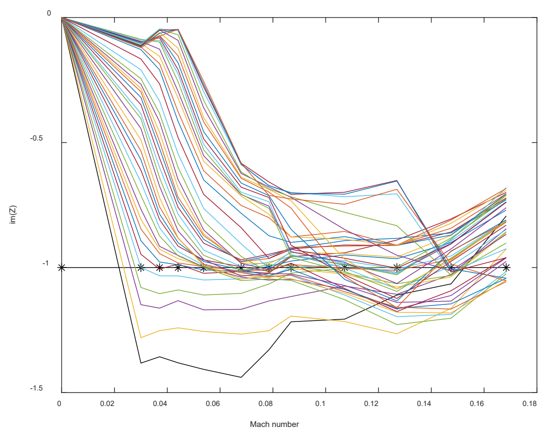

Figure 1 Effect of grazing mean flow on perforate reactance.

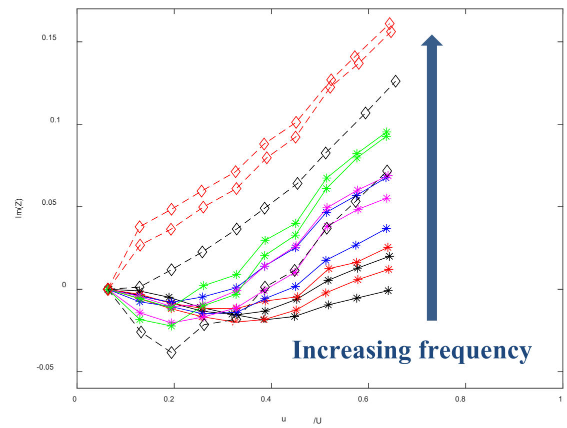

Figure 2 Effect of high level acoustic excitation in addition to grazing mean flow on perforate reactance.

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