The 32nd International Congress and Exposition on Noise Control Engineering
Jeju International Convention Center, Seogwipo, Korea,
August 25-28, 2003

[N349] An In-duct Method for Determination of Oblique Incidence Reflection Factors

Michihito Terao and Hidehisa Sekine
Affiliation: Kanagawa University
Rokkaku-bashi 3-27-1, Kanagawa-ku, Yokohama, Japan 221-8686
Email address: teraom01@kanagawa-u.ac.jp

ABSTRACT

The free-field methods for determining the reflection factor of a surface lose their validity especially when the incidence angle becomes larger than about 30 degrees and the frequency becomes lower than about 1,000 Hz even though the surface is a homogeneous flat wall, because of the contamination by the diffracted waves from the edges of the truncated test piece. To overcome the difficulties of the free-field methods, an in-duct method has been introduced here.

In this method a test piece is installed at one end of a duct, and the cross-modes of interest are excited from the other end. The complex pressure amplitudes of the incidence and reflected waves of each of the modes can be extracted from the sound pressures observed in the duct field. Numerical simulations were carried out using a boundary element approach. The effectiveness of the in-duct method was confirmed by comparing its results to theoretical ones for a locally reacting surface. By using this method, oblique incidence reflection factors have been determined for several surfaces of extended reaction such as a fiberglass-board backed with a rigid wall and a sound-absorbent wedge array.

INTRODUCTION

Determination method of the oblique incidence reflection factors of walls of extended reaction is focused on in this investigation, for specular mode reflection that governs when the wavelength is longer than the surface roughness. The free-field methods for determining the oblique incidence reflection factor of a surface lose their validity especially when the incidence angle becomes larger than about 30 degrees and the frequency becomes lower than about 1,000 Hz even for the surface of an homogeneous flat wall, because of the contamination by the diffracted waves from the edges of the truncated test piece. To overcome the difficulties of the free-field methods, an in-duct method has been introduced here. The authors utilize the fact that a potion of the sound field made by two plane waves incident symmetrically about the normal of the surface of an infinitely wide wall can be substituted by a duct field terminated with a part of the wall.

Numerical simulations were carried out using a boundary element approach. To confirm the effectiveness of the in-duct method, a comparison was made between the results by the in-duct method and theoretical ones on a locally reacting surface for which the oblique incidence reflection factors can be given theoretically from the normal incidence reflection factor that can easily be determined by means of the impedance tube method.

After the effectiveness had confirmed, the oblique incidence reflection factors have been determined using the in-duct method for several surfaces such as a 50 mm thick fiberglass backed with a rigid wall, and an array of sound-absorbent wedges of 900 mm in length directly backed with a rigid wall.

IN-DUCT METHOD TO DETERMINE OBLIQUE INCIDENCE REFLECTION FACTORS

Fig. 1 depicts the concept of the in-duct method implemented. A test piece is installed at one end of a duct, and the cross-modes for oblique incidence waves of interest are excited from the other end. The complex pressure amplitudes of the incidence and reflected waves of each of the modes can be extracted from the sound pressures observed in the duct field.

For a two-dimensional field of coordinates (x, y), the in-duct pressure $p(x, y)$ can be represented as

$$p(x,y) = \sum_{n=0}^{N} a_{(n)} \exp(-jk_x^{(n)}x)\cos(k_y^{(n)}y) + \sum_{n=0}^{N} b_{(n)} \exp(+jk_x^{(n)}x)\cos(k_y^{(n)}y) \tag{1}$$

where n and N denote, respectively, the mode order and its maximum that can be travel in the duct of the width W. $a_{(n)}$ and $b_{(n)}$ are the complex amplitudes of the sound pressures of the incidence and reflected wave of n th mode, respectively.