Proceedings of The Institute of Acoustics

Reflection of Sound Waves by Splitter Plates in Ducts +

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Problems with mode coupling can often be treated with methods based on a scattering matrix formulation. An energy conservation law often implies a unitarity relation for the scattering matrix [1]. In some cases two energy conservation laws or one energy and one momentum conservation law are known which lead to strong restrictions on the scattering matrix. This is true for the scattering of sound waves at a rigid splitter plate in a duct with uniform flow. A numerical scheme for the calculation of this problem has been described by Ko [2], [3] without presenting any numerical results.

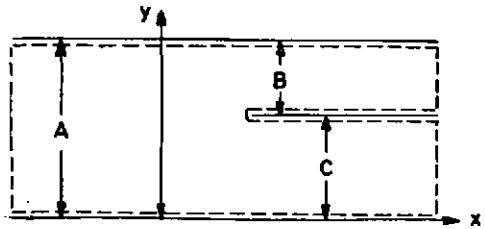

Fig. 1. The duct with the plate

An energy conservation law is an equation

$$\frac{\partial w}{\partial t} + \operatorname{div} \underset{\sim}{U} = 0 \qquad (1)$$

with w and $\underset{\sim}{U}$ being quadratic functions of the acoustic quantities.

Let ψ_1 and ψ_2 denote two possible sound fields, one finds from eq. (1) a conservation equation for the interaction energy flux $\underset{\sim}{U}(\psi_1, \psi_2) = \frac{1}{4}[\underset{\sim}{U}(\psi_1+\psi_2) - \underset{\sim}{U}(\psi_1-\psi_2)]$

$$\operatorname{div} \underset{\sim}{U}(\psi_1, \psi_2^*) = 0 \qquad (2)$$

assuming harmonic time dependence $\psi \sim \exp -i\omega t$ and assuming that the conjugate complex ψ_1^* of a sound field describes also a possible sound field. For $\psi_1 = \psi_2$ eq. (2) represents the well known conservation theorem of the average acoustic energy.

The configuration of Fig. 1 consists of three ducts A, B and C. In each of them one finds as possible waves the modes of an infinite duct, e.g. in A for the pressure

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+ This is a slightly modified version of W. Möhring, Reflexion von Schallwellen an umströmten Platten in Kanälen, to appear in Fortschritte der Akustik, DAGA 1978, VDE-Verlag, Berlin.

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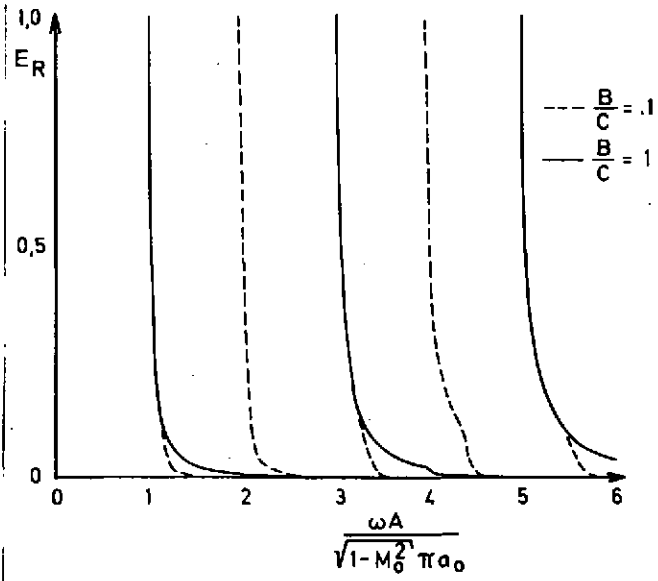

Fig. 2
Maximal reflection at the splitter plate

References

(1) W. MÖHRING 1977 AIAA-Paper 77-1280. Acoustic Energy flux in non-homogeneous ducts.

(2) S.-H. KO 1974 Journal Sound Vib. 36, 53-67. Analysis for sound attenuation in the acoustically lined annular flow duct separated by an elastic circumferential splitter.

(3) S.-H. KO 1975 Journal Sound Vib. 39, 471-487. Theoretical analyses of sound attenuation in acoustically lined flow ducts separated by porous splitters (rectangular, annular and circular ducts).

(4) R.H. CANTRELL and R.W. HART 1964 JASA 36, 697-706. Interaction between sound and flow in acoustic cavities: mass, momentum and energy considerations.

(5) O.S. RYSHOW and G.M. SHEFTER 1962 PMM 26, 1293-1309. On the energy of acoustic waves propagating in moving media.