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THE TRANSIENT PRESSURE RESPONSE WITHIN RECTANGULAR ENCLOSURES DUE TO EXTERNAL EXCITATION

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INTRODUCTION

Two major features require consideration in the transmission of airborne sound through walls, panels and windows.

The first involves the finite surrounds associated with a real situation; for example: for small panel/cavity systems, it is known that dimensions markedly influence resonance locations and transmission values [1], [2], [3]. For larger dimensions, resonance locations may not be affected, but coupling parameters are such, that "acceptable" transmission loss facilities can yield different results for the same test panel [4].

The second involves the source-time history. Most of our known or reported knowledge is given as "steady state" information, whilst most sound sources within the applied or industrial environments are transient; for example, transportation noise or shock loading. The time history involves two distinct phenomena: the effect of a spatially-transient source or incident wave as it traverses the receiver surface [5], or the transient temporal response of the system.

This presentation will concentrate upon the transient temporal response of the system; and in particular, it will simplify and extend an existing panel analysis [6] to derive expressions for the pressure response within a backing chamber.

THE ANALYSIS

The model to be examined is that of an acoustically-hard rectangular enclosure, forming a chamber at the back of a rectangular panel. This model is described in reference [2].

The analysis may be described in general terms before proceeding to a specific solution with respect to worked examples.

A pressure wave, having time and spatial variables, is incident upon the external panel surface at time $t = o$. The panel is caused to vibrate, and a velocity potential is developed within the backing cavity.

An intermediate solution for the velocity potential has been presented by Bhattacharya and Crocker [7], and may be expressed in the form of cosine transform coefficients as:

$$\psi_{mn}(x,s) = - v_{mn(s)}.\cosh.([a-x].\varepsilon(s))/\varepsilon(s).\sinh(a.\varepsilon(s)) \tag{1}$$

where

$$\varepsilon(s) = (\omega^2_{mn}+s^2)^{\frac{1}{2}}/c_o$$

and

$$v_{mn}(s) = \mathcal{L}\{V_{mn}(t)\} \tag{2}$$

that is, the Laplace transform with respect to time "t" applied to the double Fourier finite cosine transform of the panel velocity $V(y,z,t)$.

The general analysis will now follow in a manner similar to that presented by reference [7].

In a knowledge of the components of equation (1), one may determine the time variable velocity potential, that is:

$$\psi_{mn(x,t)} = \mathcal{L}^{-1}\{\psi_{mn}(x,s)\} \tag{3}$$

subsequently, to yield the cosine coefficient of pressure within the cavity via the relationship:

$$P_{mn}(x,t) = - \rho_o . d/_{dt}(\psi_{mn}(x,t)) \tag{4}$$

By two stages of Fourier cosine inversion, one may now write the total pressure developed within the cavity at any coordinate and time as:

$$P_{(x,y,z,t)} = \frac{1}{bc} \Sigma\, K.K'.P_{mn}(x,t).\cos(m\pi y/b).\cos(n\pi z/c) \tag{5}$$

The analysis, in general terms, is now complete; and whilst alternative forms may be generated ultimately to yield equation (5), the above format is suggested, because it allows a ready appreciation of functions at each stage, and also it allows one to simplify them as they are generated.

The essential difficulty in its application is the determination of a suitable panel velocity expression for insertion into equation (2). This may, however, be achieved from a consideration of formulations for the panel displacement presented in reference [6].

MAJOR FEATURES

A general analysis is presented which will enable the transient response of a cavity-backed panel to be detailed when subjected to most external forcing functions of practical interest. In addition, general functions are developed which enable final solutions to be readily achieved.

The "correctness" of the analysis is suggested by satisfying all spatial and temporal boundary conditions, and by comparison with a contemporary work for the specific case of "N" wave excitation.

Two distinct design procedures are suggested. For small cavity/panel dimensions, a simple graphical technique, based upon the work of reference [8] is employed; larger cavity/panel dimensions require more involved formulations, but solutions are shown to accomodate wave propogation time effects, that is on-set times, interference and reinforcements effects.

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