INFLUENCE OF ERROR SENSOR AND CONTROL SOURCE CONFIGURATION AND TYPE UPON THE PERFORMANCE OF ACTIVE NOISE CONTROL SYSTEMS

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ABSTRACT

An investigation is made of the influence of error sensor and control source configuration and type upon the performance of active noise control systems. The research is applied to two different cases: a discrete modal system and a continuous modal system.

i) Discrete modal system

For this case a rigid-walled duct of rectangular cross-section is examined. The number of propagating acoustic modes is determined by the duct geometry and the excitation frequency. Hence, for a given frequency, a finite number of modes are able to propagate and the system is thus modally discrete. A theoretical model is developed for ducts of arbitrary length and termination impedance, such that various duct end conditions can be examined, including rigid, infinite, open, and baffled. The model also accounts for finite size acoustic sources and sensors. The influence of the number and location of acoustic control sources is investigated, together with a variety of error sensor strategies, for the control of both plane waves and higher order modes. The system is not treated as an enclosure inside which the sound field is ideally minimised globally, but as an acoustic transmission path, with the objective of minimising the components of the sound field propagating along the duct. For this reason, it has been found more effective to minimise the power transmission downstream of the control sources, as measured by a modal decomposition technique, rather than to minimise a measure of the acoustic potential energy, as would be appropriate for an enclosure. The modal decomposition technique also enables the effect of evanescent modes to be eliminated from the error signal. This is particularly important at excitation frequencies around the cut-on frequency of each acoustic mode.

ii) Continuous modal system

The system under investigation for this case is a simplified model of a light aircraft fuselage, and consists of a finite length cylinder with an integral floor structure. This is modelled theoretically using modal coupling theory between the structure and the interior acoustic field. The structural mode shapes are determined using component mode synthesis, which combines the mode shape basis functions for the plain cylinder and the floor to obtain a mode shape function for the total structure. The two-dimensional acoustic mode shape functions are found using a finite difference implementation of the Helmholtz equation, while the axial acoustic mode shape function is equal to that of a rigid-walled one-dimensional enclosure. For the system modelled, all structural and acoustic modes contribute to the interior sound field to varying degrees, with a finite number of dominant modes contributing most to the enclosed sound field at any particular frequency. Hence, this system is modally continuous, with the objective generally being to control the dominant modes. The error sensor criteria under investigation include minimisation of the acoustic pressure at a number of microphones located within the enclosed acoustic field, which provides a practically achievable measure of the acoustic response, and theoretical minimisation of the acoustic potential energy in the enclosure. Vibrational point sources applied to the structure are used as control sources.