FLUID-LOADED VIBRATION OF THIN STRUCTURES DUE TO TURBULENT EXCITATION

Abstract

by

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Flow-induced structural acoustics involves the study of the vibration of a structure induced by a fluid flow as well as the resulting sound generated and radiated by the motion of the system. The thesis examines several aspects of flow-induced structural vibration for fluid-loaded systems. A new method, termed Magnitude-Phase Identification, is derived to experimentally obtain a modal decomposition of the vibration of a structure using two-point measurements. MPI was used to measure the auto-spectral density of various modes for a non-fluid-loaded, rectangular, clamped plate excited by a spatially-homogeneous turbulent boundary layer. These results agreed well with theory. Using MPI, it was shown that when both fluid-loading and a spatially non-homogeneous wall pressure field is applied to a structure that the mode shapes become dependent on the forcing field, an effect which does not occur when either characteristic is applied individually. Furthermore, the resulting mode shapes are potentially highly asymmetric. It was shown through a discretized string model that these results can be attributed to the increased damping induced by fluid loading. Internal acoustic wall pressure fields due to a ducted rotor were measured, and it was shown that the acoustic effects of the rotor can be
approximated by replacing the rotor with a continuous ring of dipoles located at the blade tip. The finite length of the duct was accounted for through use of a method of images. The theoretical results from this model match well with the measured values. Lastly, the vibration of a fluid-loaded duct excited by an internal rotor is measured through use of MPI. The resulting vibration field appears similar to the field examined earlier due to fluid loading, with a decrease in the coherent vibration magnitude for increasing spatial separation from the reference location.