Unstable Phenomena of a Thin Cylindrical Shell Subjected to Axial Leakage Flow

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Abstract

The unstable phenomena of a thin cylindrical shell subjected to an axial leakage flow is investigated in this paper. The analytical model is composed of an elastic shell and a rigid one that are arranged co-axially. Considering the fluid structure interaction between a shell and a fluid flowing through a narrow passage, the coupled equations of motion between a shell and a flowing fluid is derived using the Donnell's shell theory and the approximated Navier-Stokes equation. Focusing on the vibrational characteristics of a thin cylindrical shell, that is, the axisymmetric (ring-mode) vibration, the lateral (beam-like) vibration and the circumferential (ovaling) vibration, the unstable phenomena of a thin cylindrical shell are clarified by using the root locus (Argand diagram) due to the complex eigenvalue analysis. The critical fluid velocities for the divergence and flutter phenomena of a thin cylindrical shell subjected to an axial leakage flow are analyzed and defined. Moreover, comparing the uncoupled vibration modes, namely dry modes, the coupled vibration modes between a shell and a flowing fluid, namely wet modes, is shown to be considerably changed between before and after the unstable phenomena. The numerical parameter studies on the shell with both simply-supported ends are performed taking the dimensions of the shell, the characteristics of a flowing fluid and the clearance of an annular gap between the elastic and rigid shells as parameters. The influences of these parameters on the threshold of the instability of the coupled vibration between a shell and a flowing fluid are investigated and discussed.