TRANSVERSE VIBRATION ANALYSIS OF A PRESTRESSED THIN CIRCULAR PLATE IN CONTACT WITH AN ACOUSTIC CAVITY

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This paper describes the free transverse vibration analysis of a thin circular plate, subjected to in plane stretching, whilst in interaction with a cylindrical acoustic cavity. An analysis is performed which combines the equations describing the plate and the acoustic cavity to form a matrix equation which, when solved, produces the natural frequencies (latent roots) of the coupled system and associated latent vectors which describe the mode shape coefficients of the plate. After assessing the numerical convergence of the method, results are compared with those from a commercial finite element code (ANSYS). The results analysis is then extended to investigate the effect of stressing upon the free vibration of the coupled system.

Key words: *vibrations, vibro-acoustic interaction, structural/acoustic*

1. Introduction

Owing to their wide application in mechanical systems ranging from musical instruments to structural elements in industrial and space applications, the transverse vibration of circular plates and membranes has been the subject of many investigations from the end of nineteenth century. Of particular interest has been the effect upon the natural frequencies and associated mode shapes of these structural elements due to the inclusion of in-plane stressing as a result of thermal gradients and more general forms of hydrostatic loading. An excellent and extensive overview of much of this work is presented in reference [1]. In all of these studies it has been demonstrated that the inclusion of in-plane stressing can have a significant effect upon the natural frequencies of light thin plates where the restraining forces and moments due to the in-plane stressing becomes comparable, if not in excess of, the retraining forces and moments due to the inherent flexural rigidity of the plate. Much of the same body of work has shown that although the associated mode shapes are altered by the addition of the in-plane stressing, as compared to the in-plane stress free plate, the change is not so pronounced as the changes in the natural frequencies. However, these significant changes in natural frequencies, and less significant changes in mode shapes will no doubt result in significant changes in vibratory response to general dynamic loading of the plate as compared to the plate in a non pre-stressed state. Furthermore, often plates are in contact with enclosed acoustic cavities, obvious examples being musical percussion instruments and pressure vessel bursting discs. Frequency-modal characteristics for incompressible fluid in a rigid cylindrical container covered by a flexible circular membrane have

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