Vibro-Acoustic Damping Simulation of Two Laminated Glass Panels Coupled to Viscothermal Fluid Layer

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This paper numerically investigates the vibro-acoustic behavior of two thin film-laminated glass panels coupled to a viscothermal fluid layer. For this purpose, the film-laminate finite element model is coupled to the viscothermal fluid model, introducing an original configuration of a laminated double-glazing system. The two-layer laminated panel finite element is developed using Kirchhoff's plate theory and by taking into account the shear stress of a confined ultra-thin film at the skin's interface. Then, the developed equations of the laminated glass panel are based on the theory that introduces a particular behavior rule for an ultra-thin film, which includes effects of stiffness, without taking into account the film thickness. After that, the dynamic model is established in an appropriate form, including effects of viscosity and thermal conductivity of fluid and taking into account the acousto-elastic coupling. Thus, the developed finite element model is defined by a frequency-dependent symmetrical matrix system that is obtained after discretization and minimization of the coupled system energy function. Hence, a modal iterative approach is derived in order to determine the eigenmodes and vibro-acoustic responses of the film-laminated double-glazing system. The validation of the acousto-elastic model is accomplished by comparing the coupled system results against data obtained from the literature. Subsequently, several vibro-acoustic indicators, such as film-laminate strain energies and the transmission loss of the coupled system, for a specified design of a laminated double-glazing system excited by uniform pressure are presented and discussed. The numerical results show the importance of both thin film-lamination and viscothermal fluid effects on double-glazing vibro-acoustic performance.

1. INTRODUCTION

Many authors have studied the acoustical behavior of fluid-structure coupled systems such as double-wall panels. In this case, various dynamic models are developed in order to investigate the sound energy transmission.[1,2] The work developed here is originated by combining a thin film-laminated glass plate finite element model and a viscothermal fluid cavity finite element model.[3–5,21] Then, the parts of the literature review required for this study concern acoustic transmission through double panels, laminated plates' vibration containing ultra-thin adhesive films at the interface, and viscothermal losses on the fluid-structure coupled systems acoustic behavior.

In this case, we refer to some of the most important research within the literature mentioned above.

First, the reverberation transmission through a double-plate system consisting of two identical simple panels coupled to a perfect fluid cavity was investigated.[6] Next, the dynamic behavior of double glazing was studied using a finite element/boundary element method, based on a finite element formulation for both the structure and the internal fluid and an in-