Numerical model to analyze the aerodynamic behaviour of a combined conical-cylindrical shell

Youcef Kerboua, Aouni. A. Lakis

PII: S1270-9638(16)30706-4
DOI: http://dx.doi.org/10.1016/j.ast.2016.09.019
Reference: AESCTE 3782

To appear in: *Aerospace Science and Technology*

Received date: 22 February 2016
Revised date: 15 August 2016
Accepted date: 20 September 2016

Numerical model to analyze the aerodynamic behaviour of a combined conical-cylindrical shell

Youcef Kerboua[1], Aouni. A. Lakis[2,*]

[1]Mechanical Engineering Department, Constantine University 1, Algeria
B.P. 325 Route Ain El Bey, Constantine 25017, Algeria
[2]Mechanical Engineering Department, École Polytechnique of Montréal, Canada
C.P. 6079, Succursale Centre-ville, Montréal, Québec, Canada H3C 3A7

[*] Corresponding author: aouni.lakis@polymtl.ca

Abstract

A numerical model is presented in this paper to simulate the aerodynamic behaviour of combined conical-cylindrical shells. This class of structures is of great interest due to its extensive use in aeronautical and aerospace applications. Two distinct semi-analytical finite elements are used to model a combined axisymmetric shell for better geometrical consistency. The structural formulation is a combination of the finite element method and classical shell theory. The displacement functions of each finite element are derived from exact solutions of Sanders' shell equilibrium equations. The linearized first-order piston theory formula is applied to take into account the aerodynamic interaction effect. For a liquid contained in the combined shell, the fluid pressure is derived from the velocity potential, Bernoulli equation and from the impermeability condition applied to ensure permanent coupling at the fluid-solid interface. Initial stress stiffening due to axial compression and/or radial pressure is accounted for by generating an additional stiffness matrix. The elementary matrices of the solid and fluid corresponding to each finite element are calculated using exact analytical integration. Results obtained using the present approach in various conditions such as under vacuum, filled with liquid and subjected to supersonic flow are compared to those in published experimental or numerical works. Good agreement is found.

Keywords:

Conical-cylindrical shell, fluid-structure interaction, supersonic flow, frequency, finite element, stress stiffening

1. Introduction

It is well known that axisymmetric shells are widely used in many engineering applications. Their dynamic behaviour is considerably affected when are in interaction with internal or surrounding fluid. The case of cylindrical shells interacting with fluid has been extensively studied due to their widespread applications and the consistency in the theories applied to analysis of these shells. A comprehensive review is cited in references [1] to [14]. Conical shells coupled with fluid have also received some attention in recent decades but have not been as widely reported in literature as cylindrical shells. References [15] to [23] are interesting research works that have been