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Vibrational frequency analysis of finite elastic tube filled with compressible viscous fluid

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Abstract

The vibrational frequency analysis of finite elastic tube filled with compressible viscous fluid has received plenty of attention in recent years. To apply frequency analysis to defect detection for example, it is necessary to investigate the vibrational behavior under appropriate boundary conditions. In this paper, we present a detailed theoretical study of the three dimensional modal analysis of compressible fluid within an elastic cylinder. The dispersion equations of flexural, torsional and longitudinal modes are derived by elastodynamic theory and the unsteady Stokes equation. The symbolic software Mathematica is used in order to find the coupled vibration frequencies. The dispersion equation is deduced and analytically solved. The finite element results are compared with the present method for validation and an acceptable match between them are obtained.

Keywords: Frequency analysis, Compressible Stokes flow, Coupled vibration, elastodynamic.

1 Introduction

Wave propagation in liquid-filled elastic tubes since long have attracted the attention of engineers and scientists. One major application is blood flow through human arteries. Other studies involve applications in civil, oil and chemical industries, as well as biomedical and mechanical engineering.

The firm basis of the theoretical models of wave propagation in fluid-filled elastic tubes is related to the work of [1, 2, 3]. In addition, theoretical frequency analysis of viscous fluid motion has been developed by a large community of scientists. The fluid is commonly considered to be incompressible, which is valid for many cases of practical interest. It is therefore of fundamental interest to consider the case where the fluid compressibility is taken into account. This can be especially relevant to practical applications involving hydraulic fracturing. The understanding of wave propagation behavior in fluid-filled elastic tubes is of great interest in engineering, geophysics and medicine [4, 5, 6, 7, 8, 9, 10, 11]. Moreover,

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