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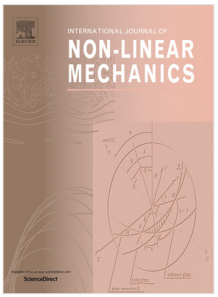

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Nonlinear dynamics of cantilevered pipes conveying fluid: towards a further understanding of the effect of loose constraints

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Abstract

The nonlinear dynamics of a fluid-conveying cantilevered pipe with loose constraints placed somewhere along its length is investigated. The main objective of this study is to determine the effects of several geometrical and physical parameters of the loose constraints on the characteristics and behavior of pipes conveying fluid. Based on the full nonlinear equation of motion, the dynamical behavior of the pipe system is investigated. Phase portraits and bifurcation diagrams are constructed for a selected set of system parameters. Typical results are firstly compared to numerical ones reported previously and excellent agreement is obtained. Then, the threshold flow velocities for several key bifurcations including pitchfork, period doubling, chaos, and sticking behaviors are predicted, showing that in many cases, the gap size, stiffness, and asymmetry of the loose constraints have remarkable effects on the nonlinear responses of the cantilevered pipe conveying fluid. For a pipe system with small/large constraint gap sizes, small constraint stiffness, or large constraint offset, some of the complex dynamical behaviors including chaos and period-doubling bifurcations would disappear, at least in the flow velocity range of interest.

Keywords: pipe conveying fluid; loose constraint; nonlinear dynamics; chaotic motion; bifurcation

1. Introduction

The understanding of the dynamics of pipes conveying fluid is of considerable interest in many engineering fields. It has application to the design of oil pipelines [1,2], pump discharge lines [3], reactor system components [4], microfluidic devices [5-8], and so on. The stability, vibration characteristics, and nonlinear vibrations are some of the key issues of the dynamical behaviors of pipes conveying fluid. Therefore, it is not surprising that the system of pipes conveying fluid has become a new paradigm in dynamics [9-11] and the literature on this topic is constantly expanding [12-18].

As the dynamics of supported and cantilevered pipes are fundamentally different, they have been treated separately. Since the early 1950s, the linear and nonlinear dynamics of cantilevered pipes conveying fluid have been studied quite extensively,

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