Non-linear dynamics of a simply supported fluid-conveying pipe subjected to motion-limiting constraints: Two-dimensional analysis

Geng Peng, Youming Xiong, Yun Gao, Liming Liu, Menghao Wang, Zheng Zhang

PII: S0022-460X(18)30524-8
DOI: 10.1016/j.jsv.2018.08.018
Reference: YJSVI 14309

To appear in: *Journal of Sound and Vibration*

Received Date: 4 April 2018
Revised Date: 29 July 2018
Accepted Date: 12 August 2018

Non-linear dynamics of a simply supported fluid-conveying pipe subjected to motion-limiting constraints: two-dimensional analysis

Geng Peng[a], Youming Xiong[a,*], Yun Gao[a], Liming Liu[a], Menghao Wang[a], Zheng Zhang[a]

[a] *State Key Laboratory of Oil and Gas Reservoir Geology and Exploration, Southwest Petroleum University, Chengdu 610500, China*

Abstract

In this paper, the coupled axial and transverse non-linear vibrations of a simply supported pipe, subjected to motion-limiting constraints, conveying pulsating fluid are investigated. The equations of motion are discretized into a set of coupled ordinary differential equations via Galerkin's method, which are then solved using Houbolt's method combined with Newton-Raphson iterative technique. The bifurcation diagrams are constructed to present the global dynamics of the system. Phase-plane portraits, Poincaré maps and power spectrum diagrams are plotted to show the characteristics of some typical motions, such as quasi-periodic and chaotic motions. Finally, the influence of axial motion on the system dynamics is investigated.

Keywords: Pipe conveying pulsating fluid, non-linear dynamics, motion-limiting constraints, two-dimensional analysis.

1. Introduction

Simply supported pipes conveying fluid have gained wide application in many engineering fields, particularly in the petroleum, chemical and nuclear industries. Therefore, various linear and non-linear analytical models are constructed to describe the motions of the pipe. The corresponding investigations of the dynamical behaviour of fluid conveying pipes mainly focus on the stability, parametric resonances and non-linear vibrations.

For a simply supported pipe conveying steady fluid flow, increasing the fluid velocity to a certain value causes the pipe to lose stability via divergence. However, if the fluid velocity is time-varying, another instability can occur, namely parametric resonance. Some notable contributions of the linear aspect were made by Chen [1], Chen and Rosenberg [2], Païdoussis and Issid [3], Ariaratnam and Namachchivaya [4], Lee *et al.* [5, 6], Liu and Xuan [7], Liu and Li [8], Tao *et al.* [9], Kjolsing and Todd [10], Deng *et al.* [11], Ni *et al* [12].

Compared to linear analytical model, the non-linear model can provide results closer to reality as it considered the non-linearity due to the deformation-induced tension and the geometric non-linearity. Therefore, this aspect has been extensively investigated in the literature [13–19]. For instance, Holmes [20] studied a modified non-linear equation of motion and showed that pipes supported at both ends cannot flutter. Namchchivaya [21, 22] investigated the subharmonic and combination resonance based on the averaging method, and the corresponding stability boundaries and bifurcation paths were obtained. Panda and Kar [23, 24]

*Corresponding author
Email address: xiongym@swpu.edu.cn (Youming Xiong)