Accepted Manuscript

Vibration response of multi-span fluid-conveying pipe with multiple accessories under complex boundary conditions

Mingyao Liu, Zechao Wang, Zude Zhou, Yongzhi Qu, Zhaoxiang Yu, Qin Wei, Ling Lu

PII: S0997-7538(17)30385-6

DOI: 10.1016/j.euromechsol.2018.03.008

Reference: EJMSOL 3567

To appear in: *European Journal of Mechanics / A Solids*

Received Date: 17 May 2017

Revised Date: 7 March 2018

Accepted Date: 7 March 2018

Please cite this article as: Liu, M., Wang, Z., Zhou, Z., Qu, Y., Yu, Z., Wei, Q., Lu, L., Vibration response of multi-span fluid-conveying pipe with multiple accessories under complex boundary conditions, *European Journal of Mechanics / A Solids* (2018), doi: 10.1016/j.euromechsol.2018.03.008.

Vibration response of multi-span fluid-conveying pipe with multiple accessories under complex boundary conditions

Liu-Mingyao[a,b], Wang-Zechao[a,b,*], Zhou-Zude[a,b], Qu-Yongzhi[a,b], Yu-Zhaoxiang[a,b], Wei-Qin[b,c], Lu-Ling[b,c]

a. School of Mechanical and Electronical Engineering, Wuhan University of Technology, Wuhan 430070, China.
b. Hubei Key Laboratory of Digital Manufacturing, Wuhan University of Technology, Wuhan 430070, China.
c. School of Information Engineering, Wuhan University of Technology, Wuhan 430070, China.

Abstract

Realistic multi-span fluid-conveying pipe may contain various accessories such as valves, clamps, flanges, elastic supports and vibration absorbers under complex boundary conditions in engineering applications. The dynamic response of the multi-span pipe may be affected by the presence of accessories, giving rise to complex mode shapes and stresses. Simplified and reliable methods for multi-span mode shapes calculation from eigenvector of the characteristic equation are widely applied in the pipeline engineering community. However, current methods are not valid when it comes to the amplitude of the eigenvector with a resonance frequency. Consequently, corresponding stresses cannot be evaluated. To address the above mentioned issues, a novel Frequency Response Function (FRF)-based method is proposed in this paper for the calculation of the mode shapes. Furthermore, a hybrid analytical /numerical method based on the Transfer Matrix Method (TMM) is developed to obtain the natural frequencies. The results calculated by the presented method are validated by comparing them with those obtained from existing literatures and conventional Finite Element Method (FEM). The effects of the accessories on the vibration characteristics of the multi-span pipes are further analyzed.

Keywords: Vibration modeling; multi-span pipes; multiple accessories; complex boundary conditions; fluid-structure interaction.

1. Introduction

The multi-span fluid-conveying pipe with complex boundary conditions and multiple accessories such as valves, clamps, hydraulic plugs, elastic supports and vibration absorbers, exists widely in the occasions of petroleum chemical industry, aerospace and nuclear engineering. Prediction of the natural frequencies of such system is the main task for the designers to avoid the resonant situation. Consequently, the dynamic analyses of a single pipe conveying fluid have been extensively performed in recent decades.

Paidoussis *et al*. studied the dynamics and stability of short tubes conveying fluid with both ends clamped or cantilevered based on the modal analysis method [1].Then, Paidoussis further studied the stability and the critical velocity of clamped-clamped, clamped-pinned, and cantilevered pipe conveying fluid with steady and harmonically perturbed flow [2, 3]. To further study the end-support and intermediate support how to