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Damage Detection in Pipes using Vibration Mode Shapes and Wavelet Analysis

Ahmad Mahdian Parrany[1]*, Mohsen Mirzaei[2]

1. Lecturer, Department of Mechanical Engineering, Vali-e-Asr University of Rafsanjan, Rafsanjan, Iran, *E-mail address:* a.mahdian@vru.ac.ir

2. Faculty Member, Department of Mechanical Engineering, Vali-e-Asr University of Rafsanjan, Rafsanjan, Iran, *E-mail address:* m.mirzaei@vru.ac.ir

Abstract

Today piping systems play a crucial role in different industries. Since pipes usually experience internal surface damages, damage detection in the pipes, using traditional inspection methods, is not possible. Therefore, finding an effective method for detecting internal damages in the pipes seems important. The primary goal of this paper is to demonstrate the effectiveness of using the wavelet transform to detect and localize the internal damages in the pipes. One advantage of using the wavelet transform is that this method requires only one static or dynamic response of the damaged structure, while no information about the intact structure is needed. In this paper, vibration mode shapes of the damaged structure are obtained using the ABAQUS numerical modeling software package, and then the wavelet analysis has been applied to detect and localize the changes in the mode shapes. The damages have been modeled as a local reduction in the thickness of the pipe and three different damage scenarios have been investigated. The continuous wavelet transform using Biorthogonal wavelet is used to get the spatially distributed wavelet coefficients. Meanwhile, a multiple-mode damage indicator based on the squared residual of the wavelet coefficients along spatial locations is proposed and its performance has been investigated via several numerical examples.

Keywords: Structural health monitoring; Damage detection; Vibration mode shapes; Wavelet transform; Damage indicator

1. Introduction

Nowadays, there are many mechanical, civil, and aerospace structures which are close or even beyond their design lifetime, and are likely to experience structural damages. Some of these structures are large and the replacement of such large structures is not economically feasible, and also the damages can be dangerous due to initiating progressive failure of the whole structure. It is obvious that an unexpected failure in a large structure such as a building or a bridge, can lead to a disastrous loss of life and have considerable cost consequences. So, it