Modeling the Effect of a Crack on the Flow-Induced Vibration of Supported Pipes

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Abstract

Flow-induced vibration analysis of pipes conveying fluid has gained its attention as the pipes are widely used in many industrial areas. Over the last decades, many studies have been conducted on the dynamic characteristics of pipeline systems subject to different loading conditions. In this paper, the effect of the crack to the flow-induced vibration characteristics of the supported pipes is investigated.

Previously, the crack identification algorithm for the rectangular beam has been developed and verified against the experimental as well as finite element analysis results. However, no published literatures have been found regarding the flow-induced vibration of pipes with crack case. A crack identification algorithm based on a mathematical model will be sought after based on this work to identify crack location and depth.

In order to estimate crack location and depth in the pipe, we need to utilize the variation of the difference between the natural frequencies of the pipe conveying fluid with and without crack. The pipe is fluid loaded via interaction with the fluid. Fluid loading has two main effects on vibrating pipes: First, the fluid mass loads the pipe, meaning that the pipe's natural frequencies are altered due to added mass. Secondly, viscous loading is provided to the pipe near the wall due to shear force between the pipe and the fluid.

In COMSOL Multiphysics®, the Aeroacoustics and Structural physics interfaces have been used for frequency domain analysis. Fully developed laminar velocity flow profile is used to simulate the fluid flow inside the pipe. Perfectly Matched Layer is used to simulate the unbounded boundary to purely capture the fluid and the pipe system without standing waves; hence the mode shapes are expected to remain unchanged for pipes conveying fluid from ones attained from pipes alone.

Reference

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Figures used in the abstract

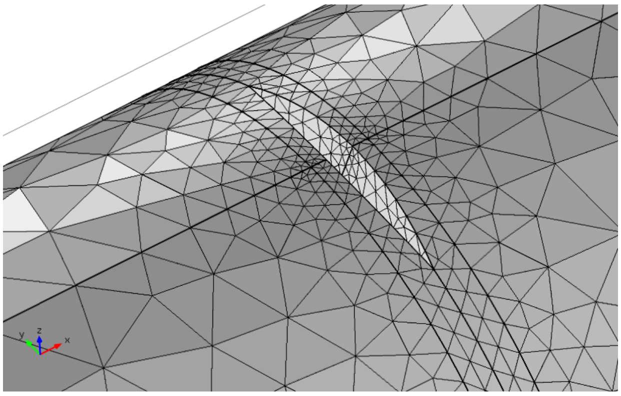

Figure 1: Zoomed in mesh at crack.

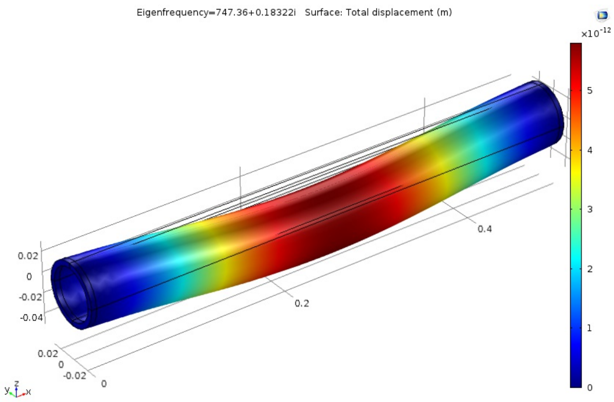

Figure 2: Mode 1 of pipe with fluid velocity at 10 m/s.

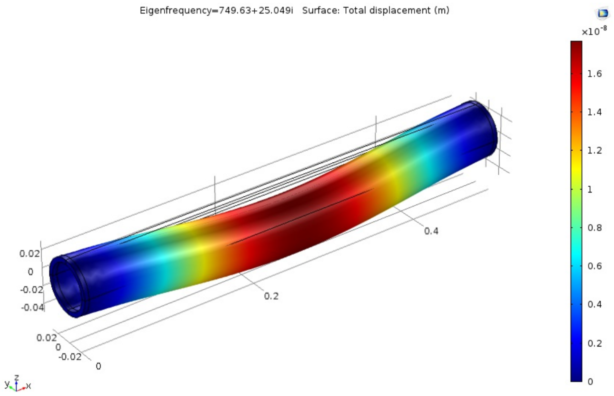

Figure 3: Mode 1 of pipe with fluid velocity at 0.1 m/s.

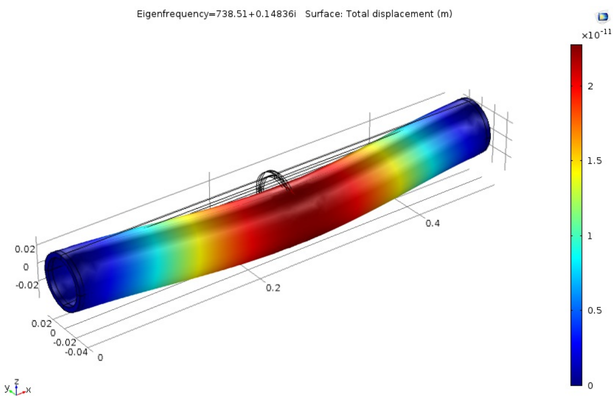

Figure 4: Mode 1 of pipe with crack at fluid velocity 10 m/s.