Insights on the impacts of multi-segmented motion limiting constraints on the nonlinear performance and stability of pipeline conveying fluid

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Abstract. Researchers have studied the nonlinear dynamics of cantilevered pipelines conveying fluid since the 1950s by introducing modifications to the system which introduce a better control of the system and many nonlinear behaviors. One of these modifications is the implementation of motion limiting constraints. Researchers have previously studied the effects of motion limiting constraints, but multi-segmented constraints are still a new topic of study. In this study, full nonlinear equations of motion will be derived and discretized, and the response of the system is validated with results from a previous study using methods of nonlinear dynamics, such as time histories, and bifurcation diagrams. Then multi-segmented motion limiting constraints are studied using similar methods. By using these two methods, the nonlinear dynamics of the system can be more accurately represented.

Introduction

Researchers have studied cantilevered pipelines conveying fluid for many decades because of its many applications. Oil pipelines and risers and mechanical pumps are just a few of the many applications of this system. Researchers have introduced motion limiting constraints and other new parameters to better characterize the system. As the internal flow speed increases, the system begins to oscillate, and eventually contacts the motion limiting constraints. This contact imposes an impact force which can cause the pipeline to oscillate chaotically at sufficient flow speeds. Another interesting nonlinear dynamic response is the grazing bifurcations that occur when the pipe contacts one of the constraints tangentially with zero speed [1]. These nonlinear characteristics have been studied by Païdoussis and his collaborators both experimentally and analytically [2, 3]. Following their work, the full nonlinear equation of motion will be derived using the extended Hamilton's. The impact force will be considering a multi-segmented nonlinear function. A Runge-Kutta based algorithm will then be implemented to find the bifurcation diagrams, time histories, and phase portraits of each system. Multi-segmented constraints are still a new topic to be researched. An example of forcing functions that represent the nonlinear cubic spring and multi-segmented constraint representations is shown in Figure 1.

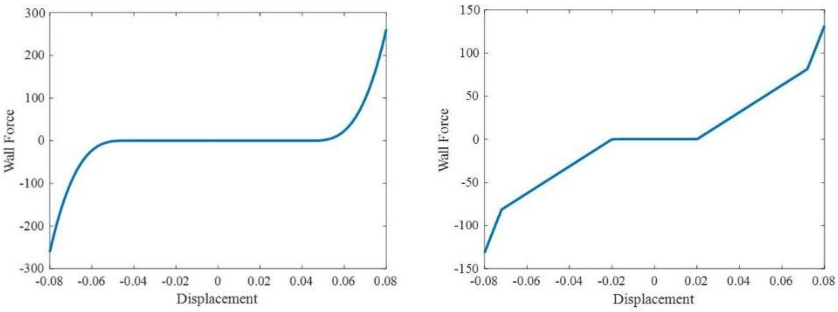

Figure 1: Forcing function estimating (a) nonlinear cubic spring and (b) multi-segmented constraints.

Current Work and Results

Once the generated reduced order model is verified to other published results, the model is then expected to produce accurate results with the novel multi-segmented motion limiting constraints. The multi-segmented motion limiting constraints will then be analyzed by studying the bifurcation diagrams, key flow speeds can be found where bifurcations take place and chaotic oscillations occur. Phase portraits can then be implemented to find a better understanding of the nonlinear characteristics of the system.

References

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