Influence of Pulsating Internal flow on Marine Riser with Nonlinear Geometry

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Abstract. In this work, we numerically explore the dynamics of inclined marine risers when it is subjected to pulsating internal fluid flow. The presence of geometric nonlinearities with static deflection makes the response of the inclined riser different from conventional top tension risers when subjected to pulsating internal flows. The riser model equation is solved via Galerkin method and validated using perturbation approaches for single mode. Then, we study the multi-modal dynamic response of the riser which reveals interesting and complex nonlinear interactions.

Introduction

Pulsating flow is a phenomenon that affects the oil and gas industries. It occurs due to abrupt perturbations and fluctuations in the internal fluid flow of the riser pipe which in return can affect and influence the vibrational motion of the structure. It occurs due to several reasons such as the nature of the multi-phase flow and sudden geometric changes [1]. Because the value of the excitation amplitude and frequency of fluctuation of the flow varies, the influence of the flow can be sever especially if the frequency of these flows are near structural resonances of the riser making them prone to failure by fatigue. On that basis, following the previous work in [2-3], the motion of the riser is analysed when it is subjected to internal flow fluctuations.

Results and Discussion

The inclined riser to be analyzed in this work is under mid-plane stretching and subjected to static deflection with pulsating internal fluid flow. The equation of the model is analyzed and solved to obtain dynamic response curves of the riser. Due to the squaring of the terms and flow of the internal fluid flow is unsteady, the excitation frequency is expected to occur at both Ω and 2Ω because of the nature of the parametric excitation. The dynamic response of the lowest three modes is depicted in Fig.1

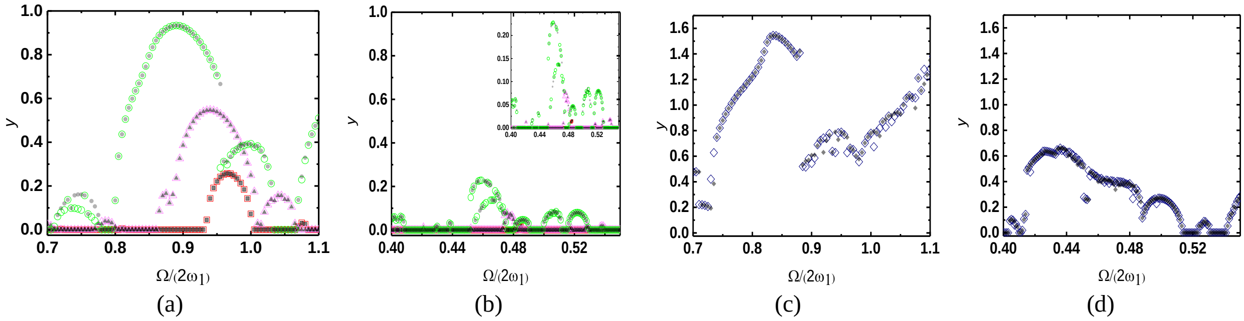

Figure 1: Frequency response curves around the first mode for $V = \sqrt{\sigma}$, $c_d = 0.416$ at x=0.48. (a,b) Backward Sweep (□) $\gamma = 0.25$, (△) $\gamma = 0.50$, (○) $\gamma = 0.75$. The inset is magnified of (b). (c,d) (◇) $\gamma = 1$. Filled shapes denotes forward sweep.

We observe, in Fig. 1, the frequency response curves for the lowest three modes of the riser. The influence of the different components that exists in the system is apparent as a result of the interaction. The softening nonlinearity effects due to the quadratic term is less apparent due to the competing effects between the first mode and contributions from other modes that exist in the response. This softening is observed very well in Fig. 1b in comparison to other cases around the secondary parametric resonance excited due to the squaring of the velocity term. In addition, the complexity of the interaction with other resonances in the response of the solution near Ω and 2Ω become more visible at higher fluctuating velocity as the solution demonstrate quasi-periodic leading to chaotic behavior. In addition, due to the nonlinear interaction, we observe the co-existence of solutions due to the presence of quadratic nonlinearities. As a result, the response of the riser reveals interesting complex and rich dynamic features.

References

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