15th INTERNATIONAL CONFERENCE
Dynamical Systems — Theory and Applications
December 2-5, 2019. Lodz, POLAND.

DSTA 2019

paper id: STA127

Nonlinear stability of a pipe conveying fluid with a spring supported end

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Abstract: Instabilities of pipes conveying fluid have been investigated for a long time. The dynamics of the lateral displacement in pipe system is described by non-self-adjoint partial differential governing equation and the eigen-functions in this problem don't belong to the system of orthogonal functions. In addition to that, it has been well known that the system shows many complex nonlinear motions. Therefore, nonlinear dynamics of pipes conveying fluid has been regarded as an essential model of the self-excited vibration in the continuous system from the view points of the non-conservative elastic problems and the flow-induced vibrations. In this study, a pipe with the spring supported end is considered. We take up the problem of double degeneracy point associated with a pitchfork and a Hopf bifurcation. In the theoretical analysis, we use the adjoint eigen-functions to project system nonlinearity to the unstable eigen-spaces. In particular, we conduct the experiments to verify the theoretical results. The experiments are conducted with the silicon rubber pipe and the lateral displacements of the pipe are measured by the image processing system. The image processing system enables us to conduct non-contact three dimensional measurements with 200 frames per second. In a certain flow velocity region, we confirm that there are three steady-state solutions (1) two stable buckled states (2) a self-excited vibrations around the straight position of the pipe.

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