Nonlinear Dynamics of circular cylindrical shells interacting with a Non-Newtonian fluid

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Abstract. This work is focused on nonlinear dynamics of a circular cylindrical shell interacting with a Non-Newtonian fluid (NN). The shell containing the fluid is harmonically excited from the base in order to investigate the complexity of the dynamic scenario. A dilatant NN fluid is considered, it is 60% corn-starch - 40% water mixture, commonly known as oobleck. The results show an extreme complexity of the dynamic scenario.

Introduction

The interaction of fluids with structures is of interest for several engineering fields such as bio-engineering or bio-mechanics but also in Medical Science. Several examples of Fluid Structure Interaction (FSI) problems can be found in Engineering: flutter (sub and supersonic), galloping, pipes instabilities, fully or partially filled tanks, heat exchangers. The human aorta is an important example of FSI with NN fluid (blood), which is highly viscous and non-Newtonian, the artery wall is hyper-elastic.

The interaction with fluids can cause several dynamic phenomena: static and dynamic instabilities; inertial effects with change of the natural frequencies and mode shapes; possible increment of damping.

The literature on FSI is mostly focused on inviscid or Newtonian fluids (compressible or incompressible). However, the Nature shows many examples of NN fluids interacting with solids and structures: blood, blood plasma, toothpaste, starch suspensions, corn starch, paint, melted butter, shampoo.

Results and discussion

In this study the nonlinear dynamics of a circular cylindrical shell, filled with NN fluid, see Figure 1, under seismic excitation is investigated. The system is harmonically excited from the base through an electrodynamic shaker in the neighbourhood of the resonance of the first axisymmetric mode. A dilatant fluid fills the shell, it is a mixture of 60% cornstarch and 40% water. The results show complex dynamics due to the coupling between the fluid and structure.

The dynamic scenario is carefully analyzed by means of time histories, spectra, phase portraits and Poincaré maps. The experiments show the onset of complex dynamics: subharmonic and quasiperiodic responses, Chaos.

Figure 1. Fluid filled shell

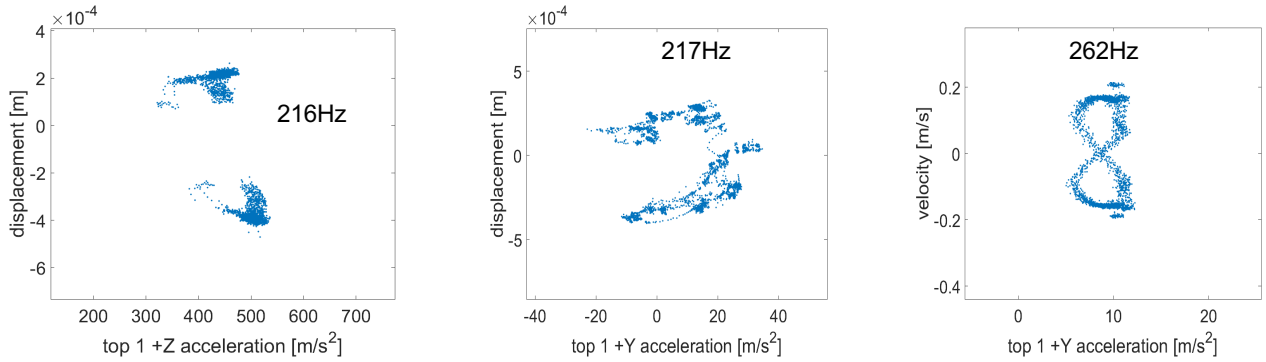

Figure 2. Poincaré maps.

References

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