Nonlinear reduced-order model of coupled fluid-structure system with sloshing and capillarity. Revisiting and explaining an experiment.

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ABSTRACT

An experiment conducted by Lindholm, Kana and Abramson in 1962 ([3]), initially designed to quantify the influence of a liquid on the elastic vibrations of a cylindrical tank, revealed an *unexpected phenomenon* of large amplitude response of the free surface of the liquid at low-frequency. When the tank was excited on some of its own resonances, a large-amplitude vibrational sloshing motion was observed. This observation was all the more unexpected since the separation of scale between the fundamental frequency of the tank and the fundamental sloshing frequency was of order 100. A second experiment [1] suggests that this unexpected phenomenon could be due to several unusual characteristics that can not yet be explained with current theories (quoted from [1]). These authors concluded that more comprehensive numerical studies were necessary for investigating the source of this phenomenon, in particular, the role played by geometrical nonlinearities effects of the tank. The present work proposes an explanation of the phenomenon observed in these experiments through a computational model based on the formulation proposed in [4], which allows for taking into account the elasto-acoustic couplings between an elastic tank with nonlinear geometrical effects and a linear acoustic liquid in the tank, in presence of linear sloshing of the free surface of the liquid with capillarity effects.This formulation brings several advantages related to the use of a nonlinear reduced-order numerical model (NLROM). The numerical results presented in this study propose an explanation for the phenomena observed in the experiments carried out in [3, 1]: the nonlinearities of the structure induce a vibratory energy transfer from the medium frequencies to the low and very-low frequencies. The energy is transmitted to the low-frequency domain from the structure through the acoustic liquid and finally, to the free surface. It can therefore be concluded that the phenomenon observed is due to an indirect energy transfer, by the geometrical nonlinearities of the tank, from the structure to the free surface of the liquid. A detailed presentation of the study is proposed in [2].

REFERENCES

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