Effects of actuator impact on the nonlinear dynamics of a valveless pumping system

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Abstract:

Valveless pumping assists in fluid transport in various biomedical and engineering systems. In this talk, we shall focus on one factor that has often been overlooked in previous studies of valveless pumping, namely the impact that a compression actuator exerts upon the pliant part of the system when they collide. In particular, a fluid-filled closed-loop system is considered, which consists of two distensible reservoirs connected by two rigid tubes, with one of the reservoirs compressed by an actuator at a prescribed frequency. A lumped-parameter model with constant coefficients accounting for mass and momentum balance in the system is constructed. Based upon such a model, a mean flow in the fluid loop can only be produced by system asymmetry *and* the nonlinear effects associated with actuator impact. Through asymptotic and numerical solutions of the model, a systematic parameter study is carried out, thereby revealing the rich and complex system dynamics that strongly depends upon the driving frequency of the actuator and other geometrical and material properties of the system. The driving-frequency dependence of the mean flowrate in the fluid loop and that of the mean reservoir pressures also are examined for a number of representative cases.

References:

1. T.-S. Yang and C.-C. Wang, preprint (submitted to J. Mech. Med. Biol., 2010).
2. M. Moser, J. W. Huang, G. S. Schwarz, T. Kenner and A. Noordergraaf, Int. J. Cardiovasc. Med. Sci. 1, 205–211 (1998).
3. C. G. Manopoulos, D. S. Mathioulakis and S. G. Tsangaris, Phys. Fluids 18, 017106 (2006).
4. A. I. Hickerson and M. Gharib, J. Fluid Mech. 555, 141–148 (2006).
5. A. S. Forouhar, M. Liebling, A. Hickerson, A. Nasiraei-Moghaddam, H.-J. Tsai, J. R. Hove, S. E. Fraser, M. E. Dickinson and M. Gharib, Science 312, 751–753 (2006).