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Addendum

Addendum to "A nonlinear model for an extensible slender flexible cylinder subjected to axial flow"

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This is an addendum to the paper by Modarres-Sadeghi et al. (2005). Its main purpose is to provide some computer animations which supplement the discussion of the dynamical behaviour of the system as described in that paper.

In Modarres-Sadeghi et al. (2005), a nonlinear model was developed for the dynamics of simply supported cylinders in axial flow. To illustrate the possible dynamical behaviour, a particular system was examined with parameters corresponding to those of an experimental system: a cylinder of length $L = 40\,\mathrm{cm}$, diameter $D = 2.54\,\mathrm{cm}$ and flexural rigidity $EI = 0.0564\,\mathrm{Pa}$, immersed in essentially unconfined water-flow of density $\rho = 1000\,\mathrm{kg/m^3}$ and variable flow velocity U. The nondimensional coefficients of the tangential and normal frictional forces were taken to be $c_t = c_n = 0.025$. The dimensionless flow velocity $\mathscr{U}$ is used as the bifurcation parameter, in terms of which the dynamics is discussed, where $\mathscr{U} = (\rho A/EI)^{1/2}UL$, and $A = (\pi/4)D^2$.

As the flow velocity is increased, it was shown that the system loses stability by a pitchfork bifurcation at $\mathscr{U} \simeq 3.14$, in agreement with previous linear analysis. The new equilibrium for the buckled cylinder becomes unstable at $\mathscr{U} = 14.23$ by a Hopf bifurcation, leading to flutter, with the cylinder oscillating periodically. This oscillatory state undergoes another bifurcation, a torus, at $\mathscr{U} = 14.73$, and the oscillation becomes quasiperiodic. At still higher flow, at $\mathscr{U} = 15.1$, the oscillation becomes chaotic.

The Electronic Annex 1 attached is a video clip showing periodic oscillation at $\mathscr{U} = 14.6$. Note that the cylinder is vertical and the flow is downwards.

Electronic Annex 2 shows quasiperiodic oscillation of the cylinder at $\mathscr{U} = 14.8$. Electronic Annex 3 shows chaotic oscillation at $\mathscr{U} = 16.0$.

Although time histories, phase-plane and PSD plots are presented in Modarres-Sadeghi et al. (2005), it was thought that this supplemental information would be of interest to the readers, particularly with regard to the modal form of the different types of oscillations.

Appendix A. Supplementary data

Supplementary data associated with this article can be found in the online version, at 10.1016/j.jfluidstructs.2006.01.003.

Reference

Modarres-Sadeghi, Y., Païdoussis, M.P., Semler, C., 2005. A nonlinear model for an extensible slender cylinder subjected to axial flow. Journal of Fluids and Structures 21, 609–627.

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