Low-Dimensional Model of a Cylinder Wake

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In a two-dimensional cylinder wake, self-excited oscillations in the form of periodic shedding of vortices are observed above a critical Reynolds number of about 47. These flow-induced non-linear oscillations lead to some undesirable effects associated with unsteady pressures such as fluid-structure interactions. An effective way of suppressing the self-excited flow oscillations is by the incorporation of closed-loop flow control. In this effort, a low dimensional, proper orthogonal decomposition (POD) model is based on data obtained from direct numerical simulations of the Navier Stokes equations for the two dimensional circular cylinder wake at a Reynolds number of 100. Three different conditions are examined, namely, the unforced wake experiencing steady-state vortex shedding, the transient behavior of the unforced wake at the startup of the simulation, and transient response to open-loop harmonic forcing by translation. We discuss POD mode selection and the number of modes that need to be included in the low-dimensional model. It is found that the transient dynamics need to be represented by a coupled system that includes an aperiodic mean-flow mode, an aperiodic shift mode and the periodic von Karman modes. Finally, a least squares mapping method is introduced to develop the non-linear state equations. The predictive capability of the state equations demonstrate the ability of the above approach to model the transient dynamics of the wake.

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