Flow-Mediated Interaction Between a Vibrating and an Elastically-Mounted Cylinder

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Abstract

This study investigates the interaction between two cylinders of an identical diameter immersed in still fluid: the active cylinder is subject to forced vibration, while the adjacent passive cylinder is elastically-mounted with a damper and has only one-degree-of-freedom along the centreline of the two cylinders. The hydrodynamic interaction is simulated with an extensively-validated 2D Navier-Stokes solver that is based on the finite element method and the Arbitrary Lagrangian-Eulerian method. In total, 23,400 simulation cases are conducted for a range of combinations of parameters. The active cylinder's oscillation frequency $f1/ fn$ ranges from 0.05 to 3.2; the amplitude of the active cylinder $A1/D$ varies from 0.025 to 1.432; the mass ratio of the passive cylinder m_* takes the value of 1.5, 1.7, 2.0, 2.2 or 2.5; the structural damping factor of the passive cylinder ranging from 0 to 1.4; the Reynolds number Rem varies from 10 to 315; the gap ratio G/D ranges from 0.2 to 3. This parametric space is chosen to reflect the values usually seen in engineering applications. With considered ranges of parameters, the solid-solid contact does not occur. The flows corresponding to regimes A, A*, C, E, F and G as classified by Tatsuno and Bearman (1990) are investigated. In all these regimes, harmonic frequency components in the response of the passive cylinder are found to persist in all regimes, causing the major and minor resonance. Even though the flow instability in regimes E, F, G causes the significant irregular frequency components to appear in low frequency. In the periodic regimes, the vibration centre of the passive cylinder can be attracted or repelled away from the active cylinder by varying the Reynolds number. The phase difference between the active cylinder and the passive cylinder's fundamental frequency component experiences a 180° shift with the increase of the active cylinder's oscillation frequency. All 6 non-dimensional parameters influence the behaviour of the passive cylinder in different ways and will be discussed in detail in this thesis. Flow patterns in the current two-cylinder case are at large similar to the single-cylinder case, although at regime C, the flow pattern is fundamentally different due to a pulse beating passive cylinder. Overall the existence of the passive cylinder adds irregularity to the flow.