Numerical Investigation on the Flow-Induced oscillation of Two Elastic Circular Cylinders in Tandem

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Extended Abstract

Flow-structure interaction in an arrangement of two cylinders in tandem is an important project for the research works of fluid mechanics, which has not been well understood. Previous works reveal some characteristics of this kind of flow phenomenon. Assi et al. (2006) investigated the oscillations of the downstream cylinder in a two tandem circular cylinder arrangement. They observed that the oscillating amplitude of the cylinder increased with the reduced velocity. For a same reduced velocity, this amplitude is 50% larger than that of a single cylinder. Kim et al (2009a, 2009b) investigated experimentally flow-induced oscillations of two cylinders in tandem arrangement for three cases, i.e., (1) the two cylinders oscillating in transverse direction with one degree of freedom, (2) the upstream cylinder being rigid, the downstream cylinder oscillating with one degree of freedom, (3) the upstream cylinder oscillating transversely with one degree of freedom, the downstream cylinder being rigid. Five wake vortex flow patterns have been observed in their experiments. Flow-induced oscillation of two cylinder in tandem has been investigated numerically by Prasanth and Mittal (2009) for a low Reynolds number of 100. In their work, mass ratio m* = 10，damping ratio $\zeta_s = 0$，cylinder spacing L/D = 5.5. They found that the variation in the amplitude of the transverse oscillation is in accordance with a three branch model which is suitable for that of a single cylinder. Numerical studies on the flow-induced vibration of two cylinders in tandem for a higher Reynolds number are still very lack. In this work, flow-structure interactions of two cylinders in tandem with two degree of freedom for each cylinder were investigated numerically, for Reynolds numbers of 200 and 1000.

In this numerical work, vortex-induced vibration of two circular cylinders in tandem arrangement with low non-dimensional mass is investigated. The computations were carried out with Galerkin finite element method, at two Reynolds numbers 200 and 1000, for one or two degree of freedom. For the case of Re=200, two cylinder spacings were chosen, L/D=3 and L/D=5, and for that of Re=1000, only one spacing was chosen, $L/D=5$. For the two cases of Reynolds numbers, the two cylinders can vibrate with one and two degree of freedom, respectively. The mass ratio is m^* = 20.0, and the non-dimensional damping ratio is ζ_s = 0.0. A dynamic model and dynamic grid technology are introduced to calculate the vibration of the two elastic cylinders. The computational domain is shown in figure1. The characteristics of flow-induced oscillation, including wake flow pattern, displacement amplitude of oscillation, lift and drag coefficients, were examined systematically.

Figure 2 shows the variations of amplitudes of transverse displacement as the reduced velocity being changed at Re=200. It was observed that the variations of amplitudes of the two cylinders present a “three branch” mode. At the initial part, the amplitudes are very small. While for the middle part, the amplitudes reach maximum values, and those for the larger reduced velocity are smaller. These results are similar to the observations of Prasanth and

Mittal (2009)'s and Bristeau et al (1987)'s. The results for Reynolds number 1000 indicate the "three-branch" mode again, and the downstream cylinder undergoes larger amplitude of oscillations in both transverse and streamwise directions. The classic VIV modes including beating and lock-in are captured while varying the reduced velocity in the whole range.

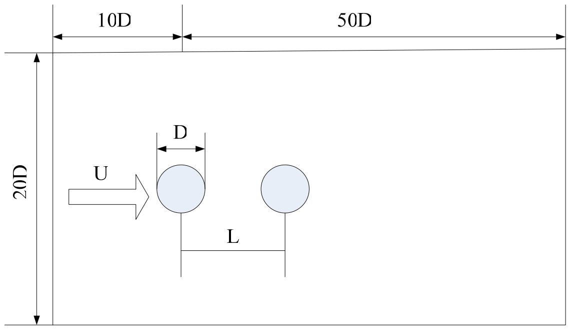

Figure 1 computational domain

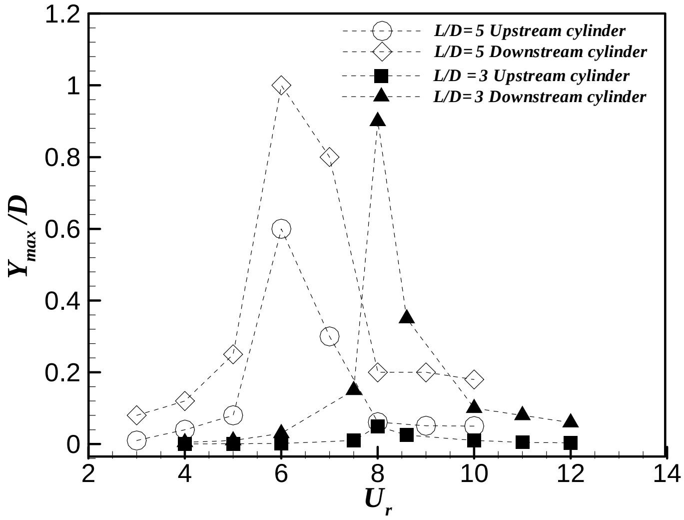

Figure 2 Variations of the maximum displacements with the reduced velocity.

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