Vortex-induced vibration (VIV) of a flexible cylinder experiencing combined uniform and oscillatory flow

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Vortex-induced vibration (VIV) is the main source of risers` fatigue damage in actual produce. In recent years, researches about VIV of a flexible cylinder in uniform, shear and stepped flow have been carried out extensively, while studies on VIV characteristic in complex flow are relatively few. In this paper, VIV of a flexible cylinder in cross-flow direction experiencing combined uniform and oscillatory flow is investigated numerically. The simulation is carried out by viv-FOAM-SJTU solver basing on the pimplyDyMFOAM solver attached to the open source code OpenFOAM. A strip theory CFD model with two-dimensional Reynolds-Averaged Navier-Stokes (RANS) equations are adopted to solve the viscous, incompressible flow field. The Bernoulli–Euler bending beam theory with the finite element method are used to obtain the structural dynamics response. The fluid-structure interaction is carried out via a loose coupling strategy by the self-compiled program.

In this paper, the focus of the study is to investigate the effect of flow ratio, α,on the VIV of the flexible cylinder experiencing combined uniform and oscillatory flow. The flow ratio is defined as the specific value of uniform flow velocity to the total fluid velocity. Simulations are carried out for the Keulegan–Carpenter (KC) number of 178. And the flow ratio varies from 0 to 1 with interval of 0.2. It is found that the flow ratio has significant influence to the response of the flexible cylinder, which leads to the difference of VIV in uniform or oscillatory flow alone. When the flow ratio $\alpha \leq 0.2$, the response of the flexible cylinder is very similar to the case of pure oscillatory flow, while that at $\alpha \geq 0.8$ is very similar to the case of pure uniform flow. The most important finding in this paper is that the combined action of uniform flow and oscillatory flow widens the lock-in regime in cross-flow direction. The cross-flow amplitude increases and decreases in one oscillatory flow period.