Detached eddy simulation of flow past a two-dimensional rotating cylinder at subcritical Reynolds number

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The lift coefficient of a two-dimensional rotating cylinder is investigated numerically for Reynolds numbers of Re_D = 10^4, 5×10^4, and 10^5 and velocity ratios of k = 0.5, 1, 2, and 4. The numerical grid is constructed using an O-type mesh with the cylinder center located 30 diameters upstream of the outlet. The grid is refined and the time step limited to maintain the maximum values of the y^+ and Courant number below one. The simulations are conducted using OpenFOAM and are run until the lift coefficient reaches a steady or quasi-steady state. The temporal mean lift coefficients for $k \leq 2$ are shown in Figure 1. For cases converging to a quasi-steady state, bars representing 95% of the temporal oscillations are included. For a given Reynolds number, a higher velocity ratio increases the lift coefficient. Holding the velocity ratio constant, increasing the Reynolds number increases the lift coefficient for k = 0.5 and 1; an effect that is notably absent for k = 2. For all tested Reynolds numbers at k = 0.5 and 1, the fluctuations in the lift coefficient are similar in magnitude, decreasing for k = 2 as vortex shedding is suppressed. For Re_D = 10^4 and k = 4, the lift coefficient converges to a steady state temporal mean of 19.7. For Re_D = 5×10^4 or 10^5 and k = 4, the lift coefficient approaches a quasi-steady state with growing oscillations suspected to be of numerical nature. The present study provides a basis for upcoming numerical studies of three-dimensional, finite rotating cylinders at critical and supercritical Reynolds numbers relevant to rotor sail applications.

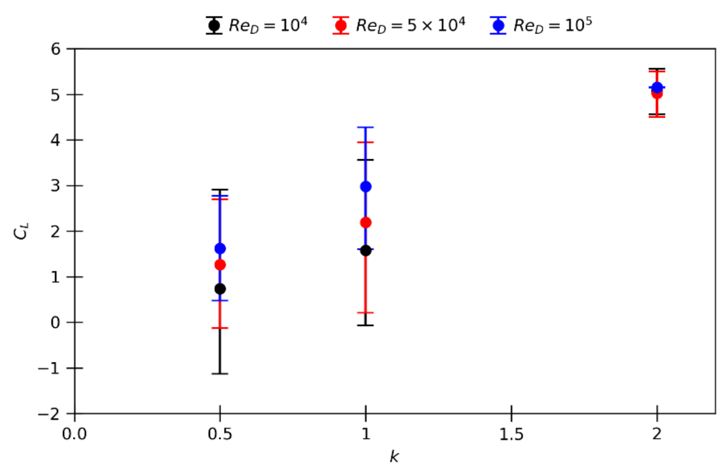

Figure 1: Effect of the velocity ratio on the mean lift coefficient of a rotating cylinder for various Reynolds numbers in the subcritical regime. Bars indicate 95% of the temporal oscillations for quasi-steady cases.

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