A NUMERICAL STUDY OF LINEAR AND NONLINEAR UNDULATORY FISH WITH THE DSD/SST METHOD

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The mechanism of animal flight and swimming is an important issue for aerial and aquatic animals [1, 2]. The linear kinematic model was used in Ref. [3], and the nonlinear kinematic model was adopted in Ref. [4]. While these two models have been extensively used, we seldom see publications reporting their hydrodynamic differences. In this work, we will study two flexible plates in tandem arrangement with the DSD/SST method. The kinematics of the plates are recorded using a vertically flowing soap film tunnel experiment, and reconstructed with both linear and nonlinear kinematic models. These reconstructed kinematics are then applied in the DSD/SST solver. The drag, lift, power consumption, vorticity and pressure fields will be discussed.

Here the swimming fish is modeled by a flexible plate. As shown in Fig. 1, two flexible plates are located in tandem in a uniform flow of velocity U. The distance between the two plates is d. The projection length (linear model) or the arc length (nonlinear model) is L. The motion of each plate is described by $y_i(x \text{ or } s, t) = a_i(x \text{ or } s)\sin[g_i(x \text{ or } s) + 2\pi ct]$, where the subscript $i = 1$ and 2 denoting, respectively, the leading plate and the trailing one, a_i is the amplitude of the motion, g_i is the phase difference, and c is the phase velocity. Here both a_i and g_i are determined by a vertically flowing soap film tunnel [5].

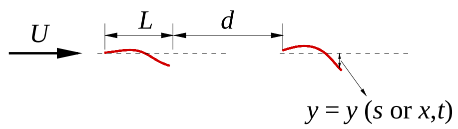

Figure 1: Schematic description of two flexible plates in tandem arrangement.

In this work, the two-dimensional incompressible Navier–Stokes equations are employed to describe the viscous fluid dynamics, which are solved with the DSD/SST method ([6, 7, 8]). Our numerical results (see Fig. 2) show that both linear and nonlinear models are able to reasonably predict the forces and power consumption of a single plate in flow. However, these two models yield totally different results when multiple plates are

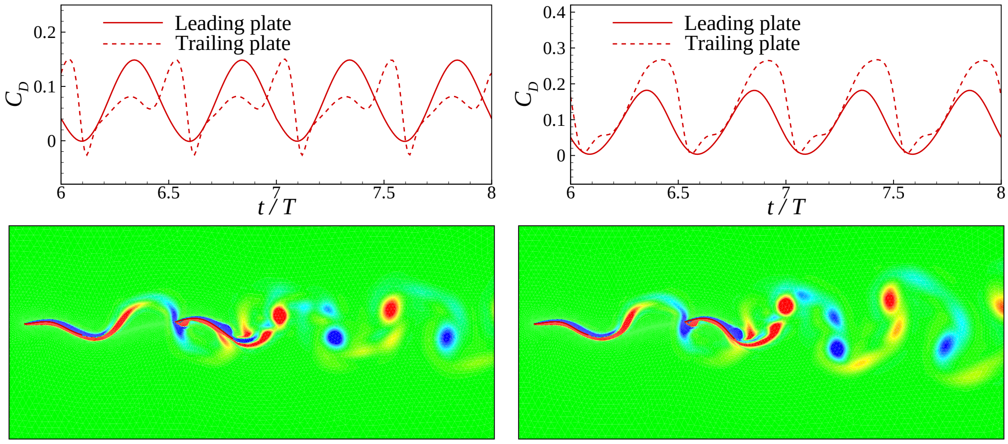

Figure 2: Drag (top) and vorticity field (bottom) for linear (left) and nonlinear (right) models.

considered, which implies that the nonlinear model should be used. The results presented in this work provides a guideline for future studies in this area.

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