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Development of a 2D Potential Flow Reduced-Order Numerical Method for the Analysis of Forces and Pressure Fields around Multiple Moving Objects or Cascades

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ABSTRACT

The hardware and numerical techniques developments of recent years have made potential flow simulations overlooked. However, these simulations remain valuable engineering tools. Their fast solution capabilities make them suitable for integration with mathematical optimizers, enabling efficient preliminary design processes.

This paper presents a method for the solution of two-dimensional, unsteady, ideal fluid flows surrounding multiple bodies or multiple cascades. The method is based on distributions of singularities (Hess and Smith, 1967) and it can handle relative movement between multiple bodies or cascades. An example with a pair of NACA0012 airfoils is present on Fig. 1 (plunging amplitude: $\frac{h_{max}}{c} = 1.0$, heave-pitch phase $\Psi = 90º$, St = 0.4, adimensionalized fore-aft distance $\frac{s}{c} = 4.0$, fore-aft phase $\phi_t = 90º$). In unsteady applications, the circulation is defined by an initial condition derived from a steady-state situation, where the starting vortex is positioned far downstream of the multiple bodies, as described in Katz and Plotkin (2021).

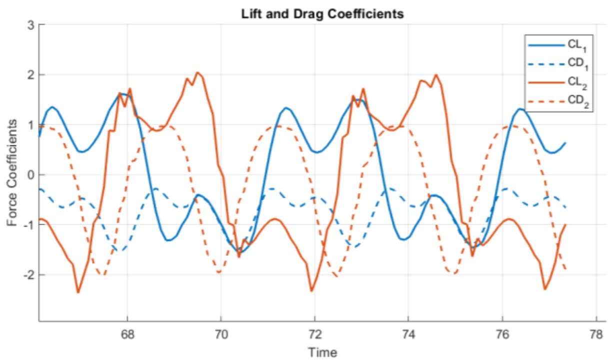

Figure 1: Coefficients of lift and drag for a pair of tandem flapping foils, one upstream (1) and one downstream (2).

Example applications include multiple flapping foils and subsonic axial ventilators. The results are compared with experimental data for pitching and plunging (Strangfeld et al., 2024) and theoretical results (Leishman and Gordon, 2006).

References

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