Multiple-Wake Vortex Method for Leading Edge Inflatable Tube Kites used in Airborne Wind Energy Systems

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In this study we propose a robust vortex model for time-dependent vortex shedding at separation locations and trailing edge. The model, which is able to capture flow separation and reattachment phenomena, aims at improving a previously developed a multiple-wake vortex lattice model [1], which could not describe flow reattachment phenomena on suction and pressure surfaces. Starting from potential theory the two-dimensional Leading Edge Inflatable (LEI) kite airfoil is discretized by several straight panels with point vortices at quarter chord point of each panel. A constant-strength vortex panel is shed at each separation location and is convected in the next time step as vortex blob without change in its strength for further time steps. The circulation is defined as a closed line integral of the tangential velocity component around the fluid element.

\[ \Gamma = \oint_C V \cdot ds \]

Considering a closed line integral around the separation panel, as described in Katz [2], applying the above equation, we get

\[ \frac{d\Gamma_s}{dt} = \frac{D}{Dt} \oint_C V ds = \frac{d}{dt} (V_i ds - V_{i+1} ds) \approx \frac{1}{2} (V_i^2 - V_{i+1}^2) \]

and \( \Gamma_{ss} \), \( \Gamma_{sp} \) are separated wake strengths defined using above formulation on suction and pressure sides respectively.

References:
