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Multi-Element Airfoil Design for an AWE Rigid Kite

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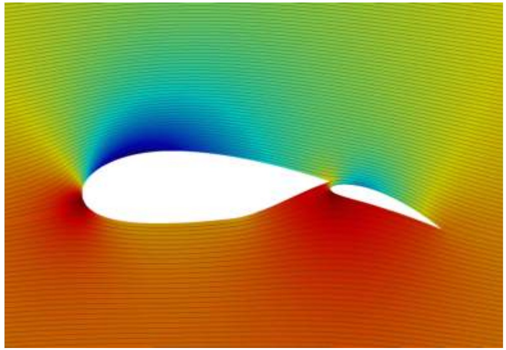
Airfoil design is crucial for the aerodynamic performance of an airborne wind energy (AWE) kite and thus also the achievable power output. Next to the aerodynamic performance, we must also consider the structural constraints.

In this study, we maximised the net power output of a high lift airfoil configuration for a 100 kW kite system operated in a pumping cycle. This optimisation requires accounting for the entire pumping cycle, consisting of reel-out (energy generation) and reel-in (energy consumption) phases with both significantly different requirements.

The parametrization of the airfoil emphasises the flap integration through a parametrised modification on the main element trailing edge. Furthermore, we identified the optimal position of the rotation pivot point of the rear element.

Our tool of choice for the airfoil design optimisation was a multi objective genetic algorithm (MOGA) because of its robustness in finding global optima in a highly non-linear design space as well as its capability of finding the pareto front, which is significant for a multi objective problem.

For analysing the airfoil aerodynamics we used MSES, which is a 2D airfoil design and analysis tool aimed at multi-element airfoils [1]. MSES solves the Euler equations using a finite volume discretization, while modelling viscous phenomena in the boundary layer and wake. For design iterations such a tool is preferred over CFD simulations because of the short computation times. The resulting optimised airfoil is verified through CFD, this method harnesses the accuracy of CFD analysis and combines it with the celerity of a lower-fidelity solver.



Pressure plot with streamlines of the multi-element airfoil.

References:

[1] https://web.mit.edu/drela/Public/web/mses/