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Fluid-Structure Interaction of Inflatable Wing Sections

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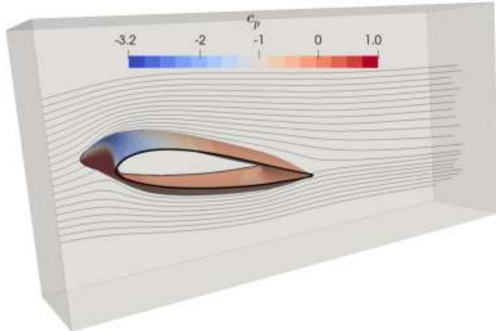
We investigate inflatable kites made of membranes such as ram-air [1] and leading edge inflatable [2] kites. The kites are very flexible and therefore exhibit a strong coupling between fluid and structure. An accurate aerodynamic model is essential to design kites which are aerodynamically efficient and of high steering capability.

In this work, a fluid-structure interaction methodology is developed to study the steady-state aerodynamics of inflatable kites. The aerodynamic load distribution is calculated using computational fluid dynamics toolbox OpenFOAM. Steady-state solver with RANS based turbulence model $k - \omega$ SST is used. The structural deformation is calculated with mem4py [2] finite element solver for membranes which uses dynamic relaxation method to find the static shape. The two solvers are coupled with preCICE [3] coupling tool. Each solver is connected to preCICE through an adapter and thereafter preCICE takes care of the coupling such as the parallel communication, the data mapping for non-matching meshes and the coupling algorithm to accelerate the convergence.

The fluid and the structure solvers are validated against relevant experiments and the coupled simulation framework is used to study the aerodynamics of a ram-air wing section with uniform pressure inside. The results show large deformations and therefore the aerodynamic loads highly depend on the structural deformations. The coupled framework shows a good compromise between fidelity and efficiency.



Pressure coefficient around the kite section and streamlines at the symmetry plane with α = 10°.

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