Fluid-Structure Interaction of Inflatable Wing Section

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ABSTRACT

Airborne wind energy (AWE) is a novel renewable energy technology for harvesting wind energy by using kites. Compared to conventional wind turbines, the AWE systems use a lightweight structure which can reach higher altitudes where the winds are stronger and more persistent. In this work, we study the steady-state aerodynamics of a ram-air kite section which is made of membranes. The inflatable structure of the kite is highly flexible and therefore exhibit a strong coupling between fluid and structure. An accurate aerodynamic model is essential to design a system which is both aerodynamically efficient and of high steering capability. The aerodynamic load distribution is calculated using computational fluid dynamics (CFD) toolbox OpenFOAM with FOAM-FSI extension [1]. The structural deformation is calculated with in-house mem4py finite element (FE) solver for membranes which uses dynamic relaxation method to find the steady-state shape. The two solvers are coupled with preCICE coupling tool [2].

Initially, the MH 92 airfoil is extruded in spanwise direction and the section is clamped at the both ends. Subsequently, the section is inflated with the stagnation pressure p_s and the FSI simulations are carried out on it. The pressure coefficient c_p around the section is shown in Figure 1 (left) and the middle section contours are shown in Figure 1 (right). The inflation of the section thickens the airfoil and rounds the leading and the trailing edge (dotted line). The aerodynamic loads further move the leading edge inwards and the shape strongly depends on the angle of attack (solid lines). The aerodynamics around the section change completely in comparison to the undeformed shape.

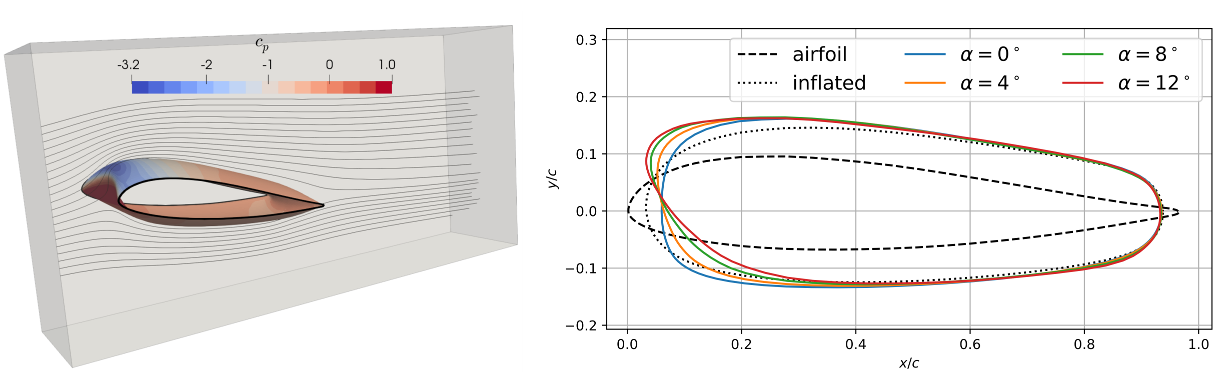

Figure 1: Pressure coefficient around the kite section and streamlines at the symmetry plane with $\alpha = 10°$ (left). Symmetry plane contour (right).

References

[1] D. Blom. *https://github.com/davidsblom/FOAM-FSI*. Accessed: 27 November 2018.

[2] H. Bungartz et al. "preCICE – A fully parallel library for multi-physics surface coupling". In: *Computers and Fluids* 141 (2016). Advances in Fluid-Structure Interaction, pp. 250–258. ISSN: 0045-7930. DOI: https://doi.org/10.1016/j.compfluid.2016.04.003. URL: http://www.sciencedirect.com/science/article/pii/S0045793016300974.