Low and High Fidelity Aerodynamic Simulations for Airborne Wind Energy Box-Wings

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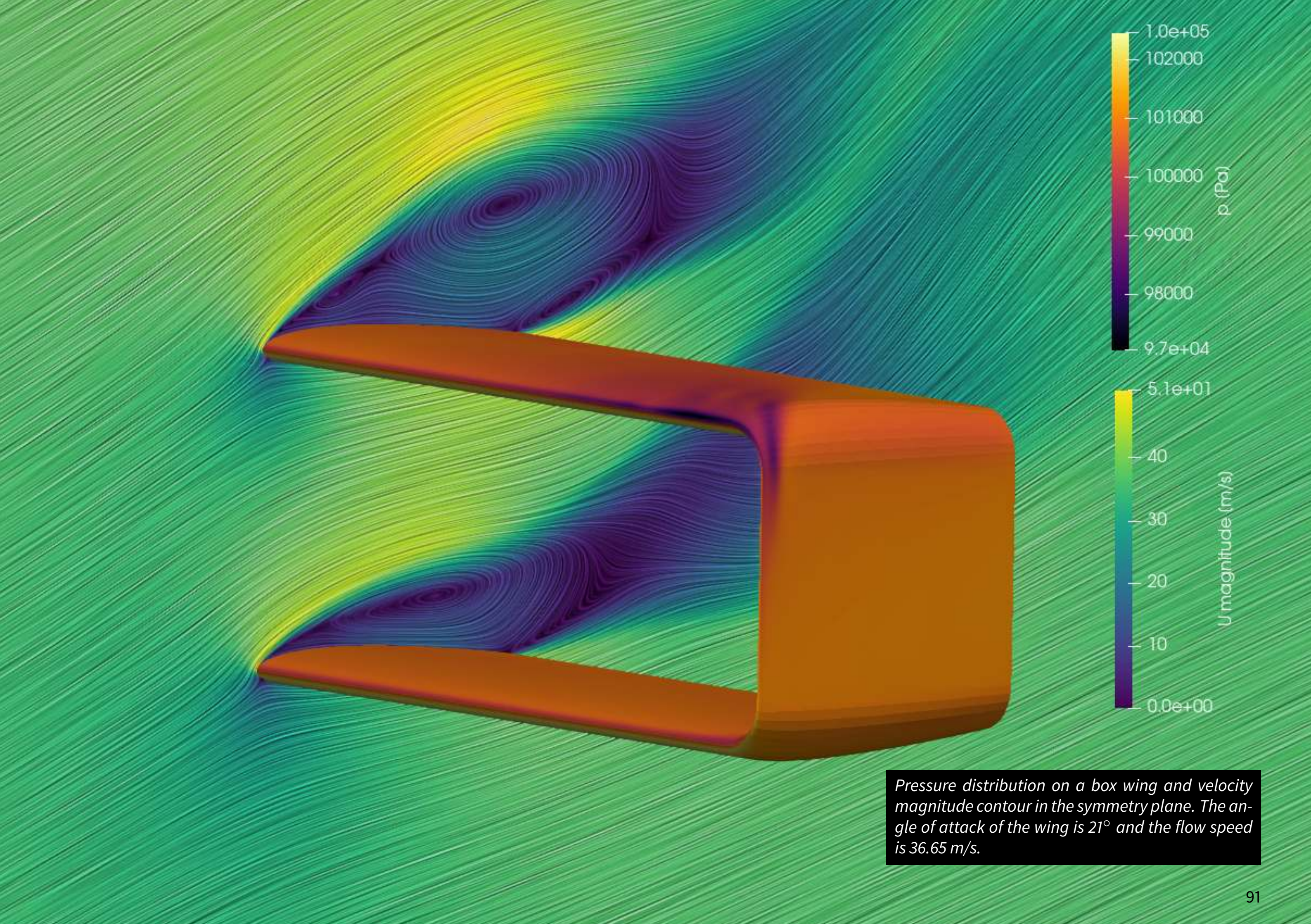
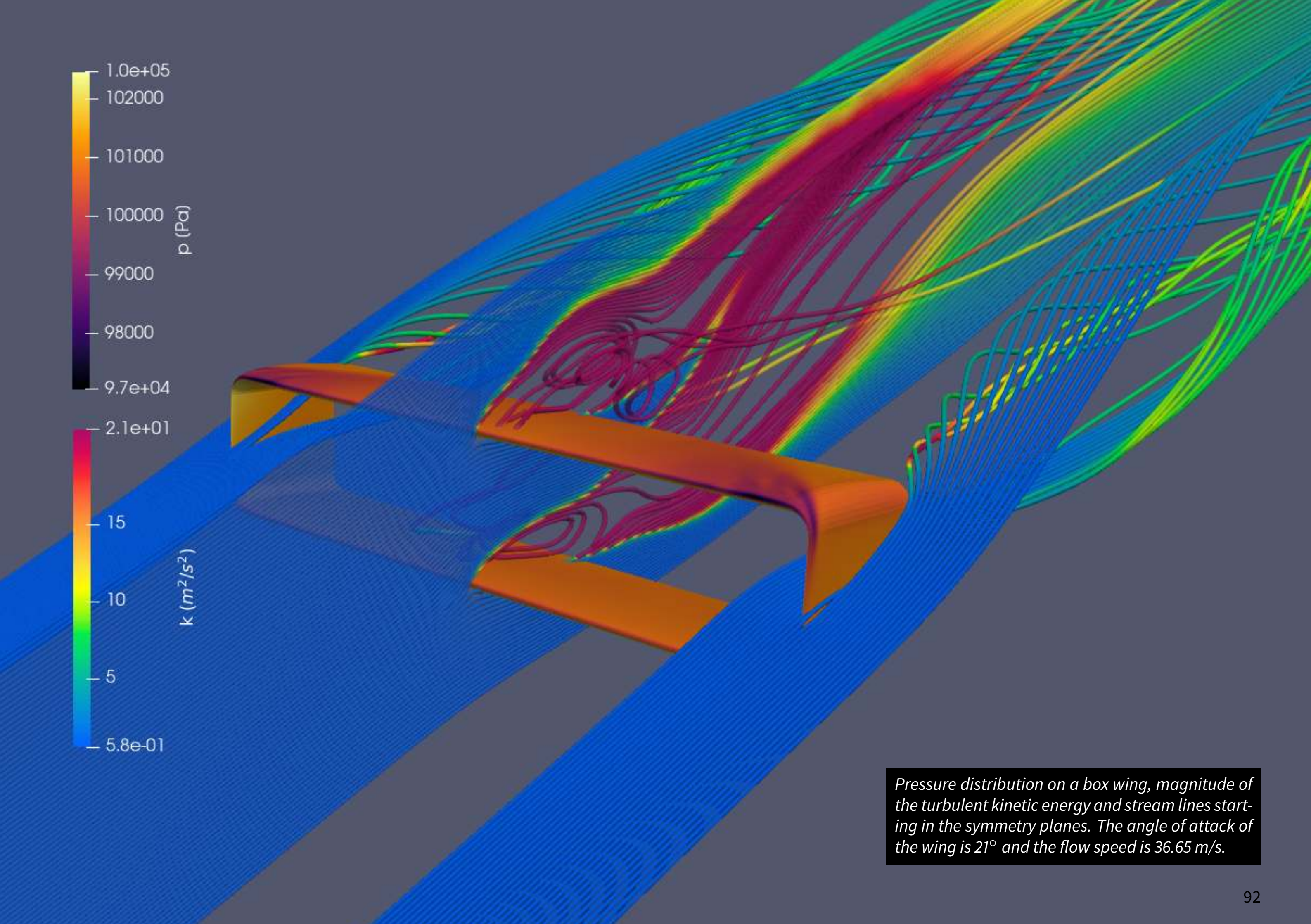


Pressure distribution on a box wing and velocity magnitude contour in the symmetry plane. The angle of attack of the wing is 21° and the flow speed is 36.65 m/s.



Pressure distribution on a box wing, magnitude of the turbulent kinetic energy and stream lines starting in the symmetry planes. The angle of attack of the wing is 21° and the flow speed is 36.65 m/s.

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Low and High Fidelity Aerodynamic Simulations for Airborne Wind Energy Box-Wings

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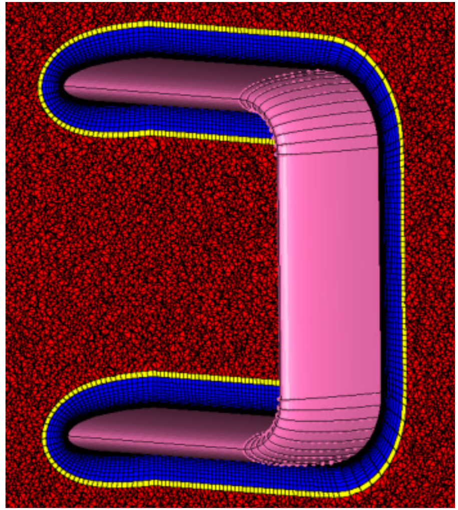
Airborne wind energy systems convert the kinetic energy of wind into usable power. In general terms, this power is proportional to the ratio C_L^3/C_D^2 of aerodynamic coefficients [1]. From a structural perspective, the thickness-to-chord ratio of conventional AWE wings needs to be high to withstand the high aerodynamic loads. The box-wing concept opens the possibility of exploring a broader range of airfoils since structural loads can be redistributed with reinforcements between the two wings. Based on theory and measurements, Prandtl concluded that the wing system giving the maximum aerodynamic efficiency (L/D) was the box-wing configuration [2].

This study aims to develop an automatic process for constructing a finite volume CFD mesh from a parametrized box-wing geometry, which is generally the most time-demanding part of CFD analysis. A further comparison of its aerodynamic performance with an equivalent conventional wing design is presented.

The aerodynamic tools used for this study are a steady panel method (APAME) and Reynolds Averaged Navier-Stokes simulations using a k-ω SST turbulence model (OpenFOAM). Both tools are validated using the results of Gall & Smith [3].

The work provides an accurate estimate of the viscous drag of box-wings. In addition, the computational framework is ultimately suitable for aero-structural optimization of a box-wing because of the high degree of automation and the reduced number of design parameters.



Example of box-wing meshing with cut planes in x and y.

References:

*[1] Loyd, M. L.: Crosswind Kite Power. Journal of Energy **4**(3), 106-111 (1980)*

[2] Prandtl, L.: Induced drag of multiplanes. Tech. Rep., (1924)

*[3] Gall, P. D., & Smith, H. C.: Aerodynamic characteristics of biplanes with winglets. Journal of Aircraft, **24**(8), 518-522 (1987)*