Flow control layout optimization

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For the enhancement of the performance of a wind turbine in terms of overall energy yield or fatigue damage often passive, retro-fit flow control devices are used. One of the earliest examples of this dating back to 1995 is the application of vortex generators to a 1000kW wind turbine to reduce the roughness sensitivity of the blades.

To maximise the energy output of a wind turbine, it important to optimize the layout of flow control devices for one or several relevant operation points. However, wind turbines operate in a highly unsteady environment with rapid changes in the inflow field due to wind shear, tower shadow, wake effects yaw and tilt misalignment as well as atmospheric turbulence. Thus, it is important to assess how these flow control devices influence the performance at off-design conditions with respect to fatigue and extreme loads, as well as aeroelastic stability. This holds true especially given the trend towards very large wind turbines for Offshore locations.

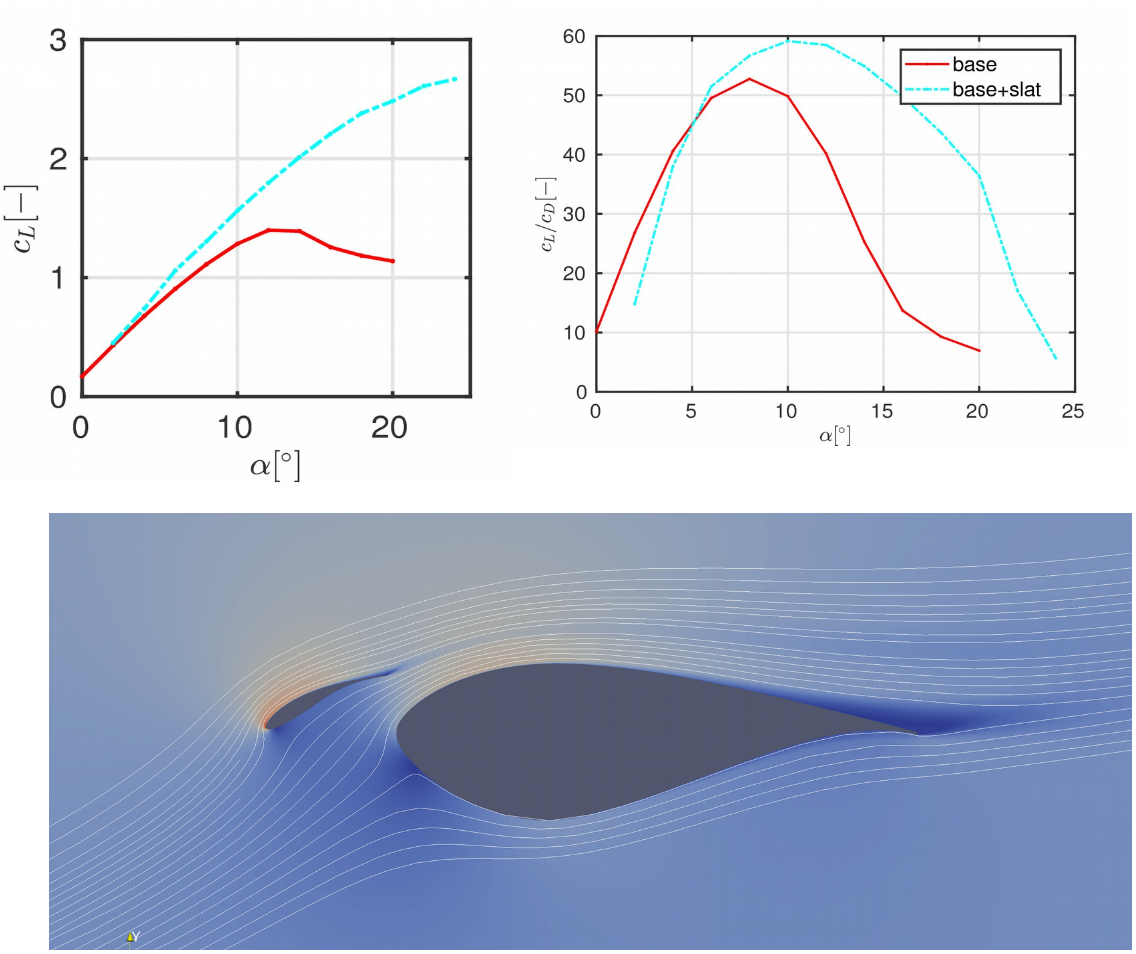
Currently, the focus of this project lies on the **design of a slat element for a thick wind turbine airfoil** with respect to steady-state and dynamic performance of the blade, as well as aeroelastic stablity.

At the more inboard blade sections usually airfoils with a high relative thickness are chosen due to structural constraints. Thick profiles generally are more sensitive to blade soiling than thinner ones. Moreover, due to insufficient blade twist the profiles also are subjected to elevated angles of attack. In order to reduce stand still loads, high lift ratios are also desired. While the aerodynamic efficiency is less important for these blade sections, it should still remain within a reasonable range.

Slat elements are interesting for these conditions, since they can delay the static stall angle and increase design lift (also see the figures on next page). Furthermore, given the location at the leading edge surface roughness sensitivity can be reduced. Moreover, it is also expected that the slat could have a positive influence on the performance of the blade under dynamic inflow conditions, such as a reduction of the load fluctuations due to dynamic stall.

The milestones are formulated as follows

- Multi-point optimization of the slat element under steady inflow conditions using IBL and CFD models
- Assessment of the performance of the element under dynamic inflow conditions such as dynamic stall
- Assessment of the performance of the clean and controlled configuration under inflow conditions relevant for **downwind turbines** such as tower shadow and yaw misalignment



Numerial results for an example base (DU97W300) and base + slat configuration at a Reynolds number of 2 million

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Slat design taken from: O. Eisele & G. Pechlivanoglou, “Single and Multi-element Airfoil Performance: Simulation Study and Wind Tunnel Validation”, DOI: 10.1007/978-3-642-54696-9_3 (2014)