

Dynamics of lift controlled wind turbine blade

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Wind turbines are installed in the strongly inhomogeneous and unsteady turbulent atmospheric boundary layer. This induces mechanical loads with characteristic time scales from seconds to minutes that limit significantly their lifetime. The present work focuses on the flow control strategy at the blade scale, to manipulate lift and thus alleviate some of these loads. A NACA654-421 airfoil profile has been modified to obtain lift control by fluidic injection at the trailing edge and an experiment has been conducted in a windtunnel, together with a companion numerical analysis, to identify both static and dynamic performances of the proposed control mechanism.

The preliminary results of the forces on the wing indicate that the lift gain obtained is proportional to the fluidic injection coefficient, which is of interest when closed-loop control is to be considered. We then focused on the pressure step-response of the flow to the actuation, measured via pressure taps located around the chord profiles, to the actuation. These measurements provided steady-state gain as well as response time, at each measured location. We provide in figure 1 (a) the steady state pressure gains, K , for different fluidic injection intensity, C_{μ} . As can be seen, the lift gain is obtained through modifications of the pressure distribution all around the chord, not only at the trailing edge where the actuation takes place. By integrating the pressure coefficient around the chord at each time step, we obtained the response curves of the lift coefficient that are plotted in figure 2 (b). The lift response is a rather slow process: it takes about 5 to 6 convective times to reach the steady state. This is twice faster than what is usually reported in stalled cases,¹ suggesting that the mechanism of lift control slightly differs when the boundary layer has separated or not.

The presentation will include analysis of the velocity flow field, as well as a more detailed wall pressure step-response analysis, providing insights on the actuation functioning.

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¹ Colonius and Willians, *Phil. Trans. R. Soc. A* (2011) **369**, 1525–1539.

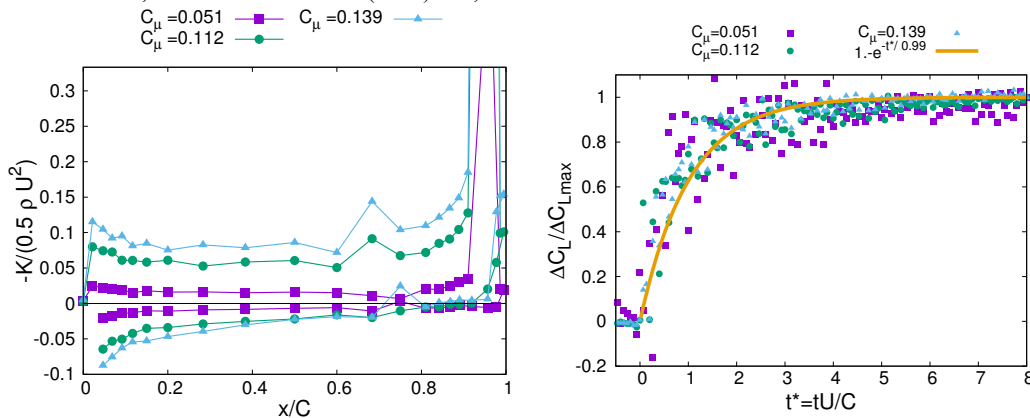


Figure 1: (a) Chordwise distribution of pressure gains. (b) Lift coefficient step-response of the system.