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Flow analysis around a high-lift wing-flap system and application of Active Flow Control to enhance the aerodynamic performances at high Reynolds number

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This study examines the physical dynamics of the use of the Active Flow Control (AFC) devices embedded inside a high-lift configuration wing-flap system. The flap is highly deflected and cambered using morphing surfaces, a separation of the flow occurs at approximately 60 % of the flap's chord leading to an important loss of the aerodynamic efficiency. Different approaches of AFC are investigated to suppress or delay the flow separation (Marouf et al. 2021). High-Fidelity numerical simulations are employed to optimise different parameters of the jet as for instance its location, orientation and intensity. The Zero Net Mass Flux approach will be investigated using the blowing-suction of a jet. The use of hybrid turbulence RANS/LES models as the Delayed Detached Eddy Simulation "DDES" is important to analyse the interaction between the separation and both the wing's and the flap's shear-layers (figure 1), which leads to a thickening of the wake width and an increase of the drag (Marouf et al. 2022). As a main results of the study, the jet delays and reattaches the flow leading to an important enhancement of the pressure distribution around the wing-flap system. These results have the potential to increase significantly the aerodynamic efficiency of the wing during the take-off and landing configurations.

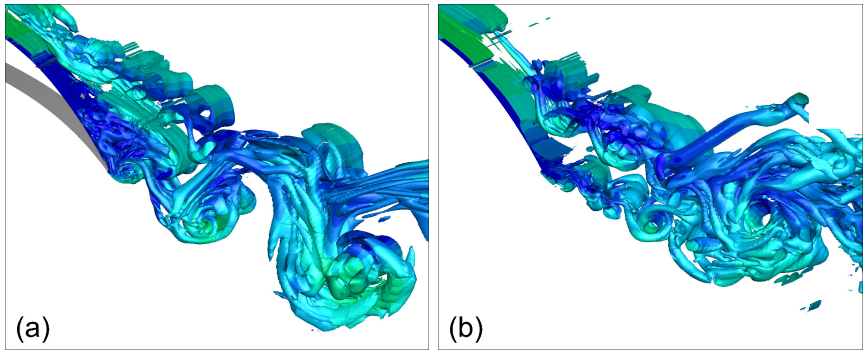

Figure 1: Q-criterion showing the region of flow separation in blue (a) located at approximately 58% of the flap's chord and the attenuation of the separation (b) by using the Active Flow Control with ZNMF with the periodic induced blowing-suction jet at a speed of $V_{jet}/U_\infty = 2.9$ and a frequency of F^+=2.38.