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Numerical simulation of the aerodynamic performance of a morphing wing in the transonic regime

César Jimenez-Navarro[1], Clément Rouaix[1], Abderahmane Marouf[1,2], Alexandre Ninet , Yannick Hoarau[2], and Marianna Braza[1]

[1] Institut de Mécanique des Fluides de Toulouse (IMFT) UMR 5502 CNRS-INPT-UT3
2 Allée du Prof. Camille Soula, 31400 Toulouse, France
cesar.jimeneznavarro@imft.fr
[2] ICUBE Laboratoire des sciences de l'ingénieur, de l'informatique et de l'imagerie, UMR 7357 CNRS-Univ.Strasbourg-ENGEES-INSA
cesar.jimeneznavarro@imft.fr

ABSTRACT

A thorough parametric study to detect optimal frequency ranges for the vibration and slight deformation of the near-trailing edge region of a morphing Airbus A320 wing has been carried out at high Reynolds number. The trailing edge of the profile is actuated by piezoactuators as in [1], whose motion has been modelled numerically using the Arbitrary Lagrangian-Eulerian (ALE) method in High-Fidelity numerical simulations with the CFD solver NSMB (Navier-Stokes Multi Block). The present work is a continuation of the numerical studies performed under the H2020 N° 723402 EU project SMS: "Smart Morphing and Sensing for aeronautical configurations", www.smartwing.org/SMS/EU framework as well as in the context of the H2020 project "TEAMAERO", «Towards Effective Flow Control and Mitigation of Shock Effects in Aeronautical Applications», https://cordis.europa.eu/project/id/860909/fr. The present study analysed the morphing effects on the transonic buffet at cruise conditions, provided by Airbus, with Mach number of 0.78 and incidence of 1.8°. It has been shown that the buffet frequency can be controlled by the morphing actuation frequency by inducing a "lock-in" effect. The present morphing approach has proven able to manipulate the near trailing edge and wake's coherent vortices and to create significant feedback effects towards the Shock-Wave Boundary Layer Interaction (SWBLI) region and even upstream of the SWBLI. The present Hi-Fi simulations have analysed the interaction between the shock-wave dynamics, wake dynamics and trailing edge actuations and studied the effects of the two main morphing parameters: actuation frequency and flapping amplitude. Furthermore, the effect of varying the actuation frequency linearly versus time (wobulation) have been quantified. It was found that a specific range of trailing edge actuations can effectively control the shock-wave's position and reduce the amplitude of its oscillation, leading to an increase of lift-to-drag ratio. Therefore, this study has shown that this kind of morphing can be considered as a promising approach from the flow control standpoint to be used in the cruise phase of flight.

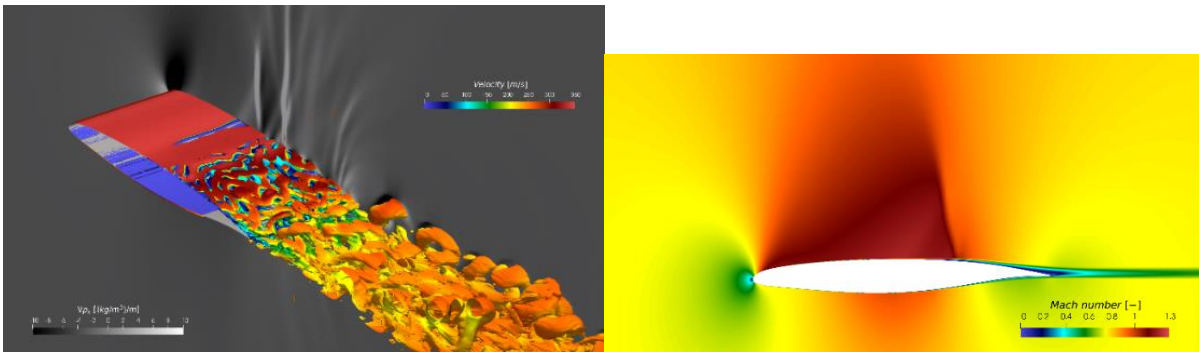

Figure 1. Left: DDES simulation showing the SWBLI structure and the secondary instability development (spanwise undulation of the von Kármán vortices). Right: reduction of the separation area and of the wake's width with the actuation frequency of 500 Hz.

REFERENCES

[1] G. Jodin, V. Motta, J. Scheller, E. Duhayon, C. Döll, J.F. Rouchon, M. Braza, (2017) « Dynamics of a hybrid morphing wing with active open loop vibrating trailing edge by time-resolved PIV and force measures », *Journal of Fluids and Structures*, **74**, pp. 263-290, https://hal.archives-ouvertes.fr/hal-01638290.