CFD and CFD-Based Optimization in Aerodynamic High-Lift Design

Jochen Wild

DLR – German Aerospace Center, Inst. of Aerodynamics and Flow Technology, Lilienthalplatz 7, 38108, Braunschweig, Germany, jochen.wild@dlr.de

Key Words: *High-lift aerodynamics, high-lift system design, aerodynamic optimization.*

Computational Fluid Dynamics (CFD) found its way into aircraft design starting with the important contributions of A. Jameson in the late 1980's [1]. First, Euler methods were implemented and in the 1990's with the rise of the Reynolds-averaged Navier-Stokes (RANS) methods [2] and the growing availability of high-preformance computers (HPC) mathematical optimization. A recent review on the spread of CFD in aircraft design has been provided by Martins [3]. Anyhow, this summary concentrates on overall aircraft and curise flight design. In high-lift system design, numerical optimization based on RANS-CFD for multi-element airfoils was introduced by Eyi et al. [4] and validated as design method by the author [5]. A review on the role of computational methods in high-lift deisgn was presented at that time by van Dam [6]. The first application of numerical optimization on a full 3D aircraft wing was reported by Brezillon et al. [7] in 2008 followed by a kind of design challenge decribed by Iannelli et al. [8].

Nevertheless, full 3D numerical optimization based on RANS is not as established for the high-lift wing as it is for the cruise condition – and this for good reasons. The lecture attempts to give some insight into some recent experience on the use of CFD methods in high-lift design, both for classical aircraft configurations [8] or for more challenging new architectures of high-lift systems [9].

REFERENCES

[1] A. Jameson, Aerodynmaic Design via Control Theory, *Journal od Scientific Computing* **3**(3):223-260 (1988).

[2] A. Jameson, L. Martinelli & N.A. Pierce, Optimum aerodynamic design using the Navier–Stokes equations, *Theoretical and Computational Fluid Dynynamis* **10**(1–4) (1998), pp. 213-237

[3] J.R.R.A. Martins, Aerodynamic design optimization: Challenges and perspectives, *Computers & Fluids* **239**:105391 (2022).

[4] S. Eyi, K.D. Lee, S.E. Rogers & D. Kwak: High-Lift Design Optimization Using the Navier-Stokes Equations. AIAA Paper 95-0447 (1995).

[5] J. Wild: Validation of Numerical Optimization of High-Lift Multi-Element Airfoils based on Navier-Stokes Equations, AIAA Paper 2002-2939 (2002).

[6] C.P.van Dam: The Aerodynamic Design of Multi-Element High-Lift Systems for Transport Airplanes, *Progress in Aerospace Sciences* 38(2):101-144 (2002).

[7] J. Brezillon, R.P. Dwight & J. Wild: "Numerical Aerodynamic Optimisation of 3D High-Lift Configurations, *26th Congress of the International Council of the Aeronautical Sciences* (ICAS), (2008).

[8] P. Iannelli, J. Wild, M. Minervino, F. Moens & M. Raets: "Analysis and application of suitable CFD-based optimization strategies for high-lift system design," *ECCOMAS 2012*, proceedings on CD-ROM, paper no. 2833 (2012).

[9] H. Strüber and J. Wild, Aerodynamic Design of a High-Lift System Compatible with a Natural Laminar Flow Wing within the DeSiReH Project, *29th Congress of the International Council of the Aeronautical Sciences* (2014).

[10] D.M. Franke and J. Wild, Aerodynamic Design of a Folded Krüger Device for a HLFC Wing, *19. DGLR-Fachsymposium der STAB 2014*, in *New Results in Numerical and Experimental Fluid Mechanics X, Notes on Numerical Fluid Mechanics and Multidisciplinary Design* **132**:17-27, Springer (2016).