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Title

Advancements in the development of a novel wing design method in Conceptual Aircraft Design

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Abstract

Recently, the authors presented a novel conceptual wing design method, which enables a detailed, transparent but still runtime-efficient design process [1]. This process, depicted in Fig. 1, uses comprehensive airfoil information stored in an aerodynamic airfoil database to map transonic effects and optionally the potential of new technologies. The aerodynamic data are used to automatically select the most suitable airfoil family and, subsequently, the optimum airfoil-sweep combination for a given input data set and design objectives. For this, a multi-criteria decision-making process is utilized. In Ref. [1], the consideration of innovative, performance-increasing technologies was demonstrated by the means of hybrid laminar flow control (HLFC). Since one objective of the LuFo VI-1 project CATeW (Coupled Aerodynamic Technologies for Aircraft Wings) is to assess the potential for aerodynamic efficiency increase by combined application of HLFC and variable camber (VC) [2], the next step in the development of the method is the investigation of whether VC can also be considered already in the wing design process. This prevents the integration of VC from being limited to an add-on solution, whose potential is naturally limited. In this work, we thereby present the advancements in the development of the design method, especially regarding the additional consideration of the VC technology.

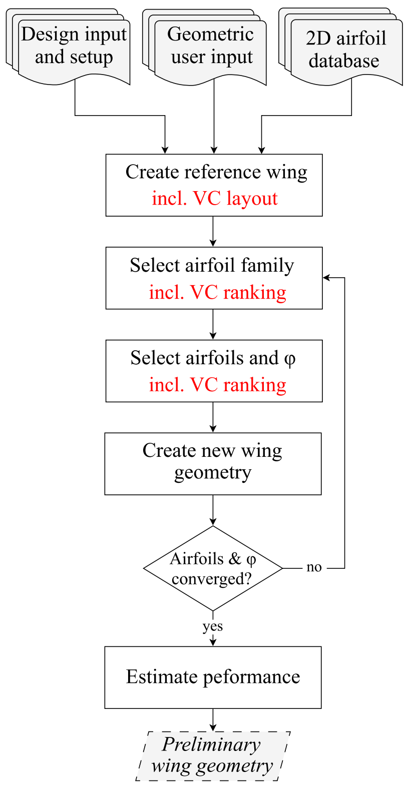

Fig. 1 - Process chain of advanced wing design (changes to the approach in Ref. [1] in red)

In the context of overall aircraft design, decreasing aircraft weight by burning fuel results in changing lift coefficients for steady cruise flight during a mission. Usually, an aircraft is optimized for one specific design lift coefficient, which inevitably leads to performance penalties when leaving design conditions. As a continuous climb during cruise, which would keep the lift coefficient constant, is not possible due to restrictions from air traffic control, step climbs are used to return to the aerodynamic optimum. The resulting sawtooth-like contour of the lift coefficient profile implies that the aircraft operates most of its mission at an off-design point. VC enables minimizing this deficit by adjusting the airfoil geometry during flight and thereby adjusting the optimum lift-to-drag ratio to the currently required lift coefficient and mission parameters [3]. Hence, the simplified idea of the enhanced approach is to select the airfoil family, the actual airfoils, and the sweep angles not only based on the design point for the clean wing but also to take the off-design performance with deployed VC flaps into account. In addition to the general approach of the wing design, Fig. 1 highlights the required changes to the existing method in red. Besides the definition of a VC flap layout and an off-design point by the user, the main changes include an additional ranking parameter for the design case. This parameter reflects the off-design performance increase due to the available VC wing permutations.

The paper starts with selected preliminary studies on the influence of the VC flap size on the aerodynamic characteristics to derive guidelines for the creation of the underlying airfoil database. After a detailed explanation of the advanced method, the work concludes with various application cases analyzing the results of the method with different user inputs.

References

[1] Effing, T., Schueltke, F., Heuschling, Y., Mauerer, P. and Stumpf, E., 'Novel Approach for Wing Design in Conceptual Overall Aircraft Design', AIAA SciTech 2023 Forum, edited by American Institute of Aeronautics and Astronautics, 2023.

[2] Jentys, M., Effing, T., Breitsamter, C. and Stumpf, E., 'Numerical analyses of a reference wing for combination of hybrid laminar flow control and variable camber', *CEAS Aeronautical Journal*, 13(4), 2022.

[3] Szodruch, J., 'The Influence of Camber Variation on the Aerodynamics of Civil Transport Aircraft', AIAA 23st Aerospace Sciences Meeting, edited by American Institute of Aeronautics and Astronautics, 1985.