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Validation Task for Solution of Optimal Slotted Flap Position Using FLUENT Software

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Abstract: CFD solvers are commonly used in optimization problems in aerodynamics. Typical task is the search for optimal position of slotted flap. It is shown on the example that the optimum predicted by CFD software can differ significantly from that found in the wind tunnel. The paper presents results of the validation task with different meshing grids and turbulent models. In conclusion, the authors suggest topics for further investigation in this field.

Recently, more complex and sophisticated optimization methods are coming into use in the field of aerodynamics. These mathematical algorithms are usually coupled with CFD solver generating the input for the optimization. Hence, the accuracy of whole process strongly depends on error of results obtained from CFD caused by low quality of computational mesh, inappropriate turbulence model, wrong settings of initial and boundary conditions, etc. Therefore only the code validated for the task should be used, otherwise the result of the optimization will not match the real optimum and traditional design methods based on engineer's experience could give better solution for much lower cost.

Detailed review of published validation cases with high-lift configuration was made by Rumsey and Ying [1]. It is summary of the data comparison of measurements and computations on 2D and 3D multielement airfoils with general recommendations on computational domain size, mesh density or compressibility corrections. Unfortunately, common practice is to examine the flow only for one geometrical configuration, which helps to increase the accuracy of the stand-alone analysis, but can be insufficient for a complex aerodynamic optimization.

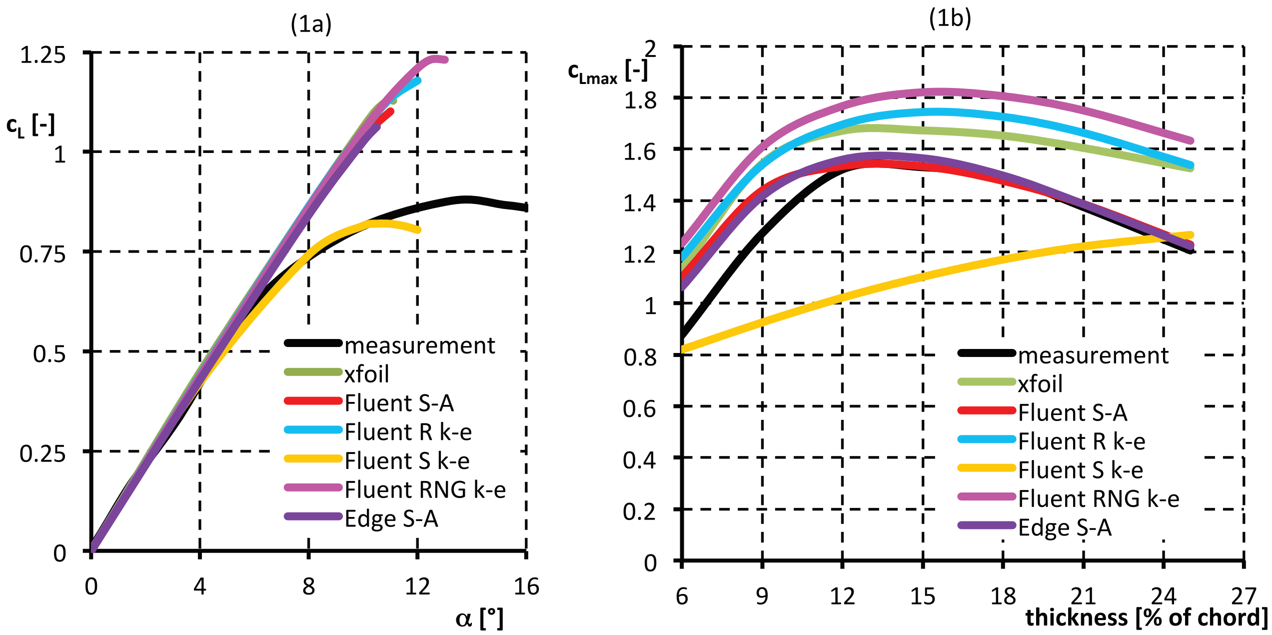

Fig. 1: Comparison of results from computations and measurement: (1a) lift curves at one design point, (1b) maximum lift coefficient through entire design space

It is shown in Fig. 1 that the best agreement with measurement at one point does not necessarily mean the best agreement in the entire design space. It is a very simple example of search for a symmetrical airfoil from NACA four-digit family with the highest lift coefficient. Aerodynamic characteristics were calculated using panel method solver Xfoil and CFD codes Fluent and Edge with different turbulence models. If the selection of the solver is based on just one of possible geometries (NACA 0006), Fluent with standard k-ε model of turbulence would be chosen, which predicts the optimum which is far from that obtained from tunnel measurements.

This is a basic validation task with only one variable changing and it is obvious that a turbulence model with results corresponding closely with measurement through the major part of the design space can be found. But further topics to be discussed arise, like whether or not it can be found also for design spaces with more variables and about applicability of such simple validation tasks to solution of more advanced problems.

Typical two-dimensional task, as a next step in validation, is positioning of slotted flap. Many engineers are satisfied with simple calibration of the most common solver they use, but they do not check its overall capability to solve the problem correctly. This was the motivation for authors to investigate and compare computed and measured data for wide range of flap settings. Airfoils were selected according to availability of measurement results needed. In this paper, current state of the work is presented and topics for further study are discussed.

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