Aerodynamic performance of the high-lift laminar wing at free flight and ETW in-tunnel conditions

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The work presented is performed in the frame of DESIREH project (FP7) funded by EC. This project intends the realization of the ACARE Vision 2020 for significantly greener aircraft and a reduced time to market by improving the aerodynamics of the High-Lift system. This should be achieved by considering - at the same time and in coordinated approach - the numerical design methodology, the measurement techniques for cryogenic conditions for an advanced laminar wing design to be performed in DESIREH. The final aerodynamic tests of the high-lift aircraft model were performed in ETW. The main goal of TsAGI team was to estimate the effects of wind-tunnel walls on the model characteristics. In order to achieve this goal three series of computations were done. There are calculations for the model in a free flight environment and for the model installed in the wind tunnel both with open and closed slots.

The model under consideration consists of the fuselage and high-lift wing supplied with deflected Kruger slat and deflected flap. Calculations were performed for the Mach number M=0.2, incidence angles α= 0°, 5°, 10°, 12°, 14° – 25°, with Re number equal to 16.4 million. The computational grid for the model in a free air environment contains 14.5 million cells. In the case of the model inside wind tunnel test section the grid contains 20 million cells. A multi-zonal structured grid approach has been selected for the present work. All calculations are performed using TsAGI in-house code EWT-TsAGI. The numerical method of this package is based on the Godunov-Kolgan-Rodionov (GKR) approach. It includes the original vector-minmod function and a modified two-equation k-ω turbulence model.

The comparison of experimental and computational values of CL of the model installed in wind tunnel with closed walls is presented on Figure 1. These results are in good agreement with experimental data. It should be noticed that experimental data were obtained after all computations were ended (no tuning were used).

The presence of wind tunnel walls leads to growth of lift (see Figure 2) due to contraction and acceleration of flow above the wing and due to deceleration from below, in the case of positive incidence angles (ΔCL$\approx$0.08). At that, closing the slots intensifies this effect and gives the growth ΔCL$\approx$0.17. When the stall takes place (α=19° without correction), on the contrary, the influence of walls results in lift diminishing. In the case of critical regime, this additional contraction of flow results in decrease of stall angle. For the given aircraft model, the stall angle diminishes for about 1° in WT with open slots and for about 2° in WT with closed slots.

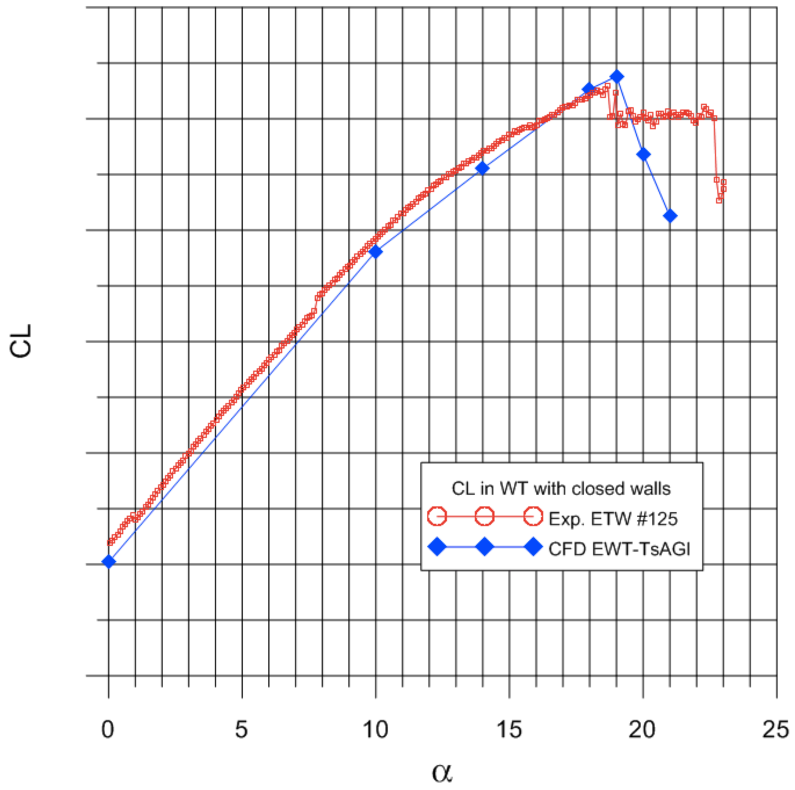

Figure 1 The comparison of experimental and calculated data

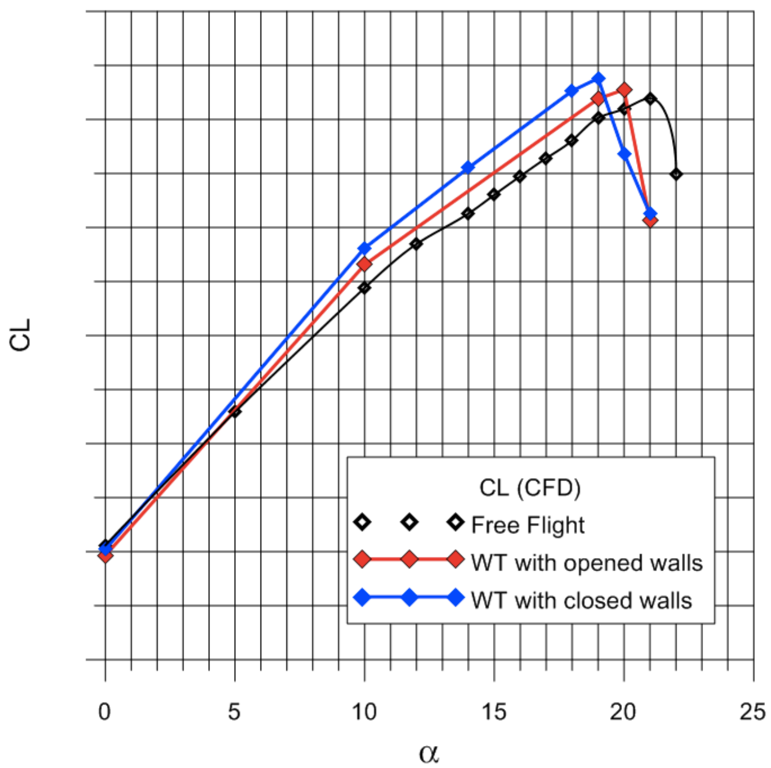

Figure 2 Lift coefficient for free flight and wind tunnel environment