

Validation of Open-FOAM as computational fluid dynamics software through experimental aerodynamics

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This research aims to validate the Open-FOAM (Field Operations and Manipulations) by conducting aerodynamic testing on the Clark Y 14 (CY14) aerofoil model with an Educational Wind Tunnel (EWT). The lift - c_l and drag - c_d coefficient variations of the model have been experimentally measured for Angle of Attack (AoA) ranging from -8° to $+20^\circ$. Further, the total drag that acted on the CY14 was separately measured using the wake survey method.

According to the general trend, Computational Fluid Dynamics (CFD) underestimates the lift coefficient compared to wind tunnel experiment. It is as high as 24 % at a low AoA, but it reduces to 9 % at a higher AoA. However, both methods reveal that the aerofoil behaves in linear fashion for AoA ranging from -2° to $+6^\circ$ having the same lift curve slope of 0.1 / degree. Moreover, the CY14 has a maximum lift at 12° and stalls at 14° .

The predicted pressure drag coefficients were much lower compared to CFD and wake survey methods as expected. Nevertheless, a considerable overestimation of the pressure drag was observed for high AoA. This could be related to insufficient pressure taps towards the trailing edge (TE) of the aerofoil. When considering wake survey drag results, the simulation values were more than twice the experimental values. These high values were due to the fact that though CFD turbulence models generally assume a complete turbulent flow within the boundary layer (BL), in reality, an aerofoil has a mixed BL (A combination of laminar and turbulent flow).

In conclusion, Open-FOAM numerical simulations underestimate lift of CY14 airfoil compared to wind tunnel testing. Although the direct root cause for this cannot be figured out, it may be related to the refinement level of the computational mesh. A new turbulence model which is capable to handle a mix flow within the boundary layer is essential for more accurate estimations of the drag. In spite of inaccuracies of numerical values, Open-FOAM has predicted an overall aerodynamic behaviour of the CY 14. Therefore, new software could be used for aerodynamic designs, but that may generate slightly over designs.